WATERSHED WORK PLAN

LLAGAS CREEK WATERSHED

Santa Clara County, California
June 1962

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LLAGAS CREEK WATERSHED

SANTA CLARA COUNTY, CALIFORNIA

Prepared under the authority of the
Watershed Protection and Flood Prevention Act
(Public Law 566, 83rd Congress; 68 Stat. 666), as amended

Prepared by

Loma Prieta Soil Conservation District
Santa Clara County Flood Control and Water Conservation District
South Santa Clara Valley Water Conservation District

With assistance by

Resources Agency of California, Department of Conservation,
Division of Soil Conservation
Division of Forestry
and
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Soil Conservation Service
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PROJECT MAP



U.S. Highway 101 three blocks north of Miller Slough, Dec. 1955. Flood waters from Miller Slough flow across the Highway and Railroad and into the "BE-GE" industrial plant, center right.



Walnut Lane Tract, Northeastern Gilroy, Dec. 1955. Local runoff, unable to flow into Miller Slough at flood stage combined with overflow water from Llagas Creek, creates a serious flood hazard in this residential area.

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SUMMARY OF PLAN

That portion of the Llagas Creek Watershed included in this work plan contains approximately 34,600 acres in south central Santa Clara County. Llagas Creek drains portions of the south Santa Clara Valley and the Santa Cruz Mountains to its west before discharging into the Pajaro River, which flows past the city of Watsonville and discharges into the Pacific Ocean at Monterey Bay. Gilroy and San Martin, the urban centers within the watershed, are already feeling the impact of the fastest growing metropolitan complex in the United States--San Jose, only 30 miles to the northwest. However, within the contemplated 50 year project life, the predominant land use within the watershed is expected to remain agricultural.

Major flooding has inundated large areas within the watershed 12 times in the last 60 years. Historically, about one-half of the 10,000 acres in the lower watershed has been inundated by one single flood, and nearly every portion of this area has been subjected to flooding at one time or another.

The sponsors propose to solve the flood problem through the application of both land treatment and structural measures. The land treatment program will include such on-farm measures as farm ponds and range seeding, as well as intensified fire protection on the brush and forest lands. The structural works will include increasing the capacity of an existing water conservation reservoir to provide flood detention space, as well as building or enlarging over 20 miles of flood channels on Llagas Creek and its tributaries. All structural measures will be designed to contain a flood of such magnitude that there is only one chance in a hundred of it occurring in any given year.

The total cost of installing these land treatment and structural measures is $7,949,300, of which $4,824,040, or 61 percent, will be from Public Law 566 funds. The remaining $3,125,260, together with $39,800 annual operation and maintenance cost, will be borne locally. It is anticipated that $341,240 will be expended the first year on all measures and $1,230,020, $1,505,680, $1,679,820, $1,971,140, and $1,221,400, respectively, during the subsequent years of a six-year period.

The total average annual cost of the structural measures, including amortized installation plus operation and maintenance, is $303,200. Comparing this with $635,400 of anticipated average annual benefits yields a benefit-cost ratio of 2.1 to 1.0.

This work plan is jointly sponsored by the Santa Clara County Flood Control and Water Conservation District, the South Santa Clara Valley Water Conservation District, and the Loma Prieta Soil Conservation District. The Flood Control and Water Conservation District will be the local agency responsible for project installation and operation and maintenance. Land treatment measures, other than those for fire protection, will be installed and maintained by individual farmers and ranchers cooperating with the Soil Conservation District. The Santa Clara County Flood Control and Water Conservation District will carry out the intensified fire protection plan with assistance from the California Division of Forestry and the U. S. Forest Service.

The above agencies participated in the technical planning, together with the Soil Conservation Service of the U. S. Department of Agriculture and the Division of Soil Conservation of the Department of Conservation of the Resources Agency of California.



Photo #1



Photo #2



Photo #3



Photo #4

FLOOD PHOTOGRAPHS - FEB. 15, 1962

WEST BRANCH OF LLAGAS CREEK

Photo #1 : 3/4 mile north of Highway 156, west side of Morey Avenue looking north.

Photo #2 : 3/4 mile north of Highway 156, west side of Morey Avenue looking west.

Photo #3 : Day road between Morey Avenue and Highway 101 looking northwest.

Photo #4 : Murphy Lane between Day and Fitzgerald Roads looking west.

DESCRIPTION OF THE WATERSHED

Physical Data

The Santa Clara Valley extends from the southern tip of San Francisco Bay to Hollister about 50 miles to the southeast. The north end of the valley drains into San Francisco Bay, and the south end drains into the Pajaro River and thence westward into Monterey Bay through a gap in the Santa Cruz Mountains. During periods of high runoff, Pajaro River water is backed up onto the Santa Clara Valley floor to form Soap Lake. Llagas Creek flows into Soap Lake from the north, draining the valley floor area as well as a portion of the Santa Cruz Mountains to the west and a small foothill area to the east. Of the 50,861 acres tributary to Llagas Creek where it enters Soap Lake, 34,621 are within the watershed area analyzed for this plan; and the balance is in the tributary Little Llagas Watershed. Little Llagas Creek enters Llagas Creek from the east about six miles upstream from where the latter enters Soap Lake and drains an area of about 25 square miles to the north and east of the Llagas Watershed.

Approximately 45 percent of the Llagas Watershed, as shown on the Project Map, is comprised of valley floor area. This area, roughly 12 miles long and from 1 to 3 miles wide, ranges in elevation from 150 up to 350 feet above sea level. It is mostly highly productive agricultural land with fruit and vegetable crops predominant and grain and pasture crops located around the fringes. About 3 percent of the valley land is presently devoted to urban uses; however, this percentage is expected to multiply several times during the life of the project. Nevertheless, the predominant land use is expected to remain agricultural for many years to come.

East of the valley floor, steep, lightly vegetated hills rise to 1,600 feet in elevation. Presently this 5 percent of the watershed area is range and brush land.

The remaining 50 percent of the watershed is located west of the valley floor in the foothills of the Santa Cruz Mountains. These hills are similar to the east side hills in their lower elevations, but become progressively more densely wooded as the elevation increases to 3,562 feet at the peak of Mt. Chuai. The predominant native cover is brush, although minor areas, particularly on the shallower soils, are grassland. Native trees are found along the higher ridges and drainage ways. The flat areas immediately adjacent to Llagas Creek are devoted largely to orchard.

Llagas Creek has its headwaters on the slopes of Mt. Chuai and flows through densely wooded hills for its first seven miles. For the next 10 miles it flows through a narrow valley as it drains the hills on both sides through numerous small tributaries. Midway in this reach the South Santa Clara Valley Water Conservation District has constructed 7,630 acre-foot Chesbro Reservoir which inundates 275 acres. In the 11 miles it flows along the floor of the Santa Clara Valley within an alluvial channel, Llagas Creek intercepts Little Llagas and several smaller creeks from the east and Miller Slough from the west. Altogether it is about 28 miles from Mt. Chuai to Soap Lake along the Llagas Creek channel.

The soils within Llagas Creek Watershed can be placed within three main types. Fairly deep residual soils have developed on sandstone, shale, and igneous rocks within the uplands even though the parent rocks outcrop over large areas. Although the soils overlying the igneous rocks are usually heavy textured, medium to light textured soils have developed on the more widespread sedimentary rocks. The higher land within and along the margin of the valley floor is generally older alluvium. The soils are medium to heavy textured with well developed surface drainage but poor subdrainage caused by accumulations of clay in the subsoil. The largest percentage of agricultural soil is developed on younger alluvium that is locally still being deposited. These soils have immature profiles and are generally light textured; however, local concentrations of calcium carbonate restrict water movement. The aquifers presently being recharged through the percolation area on Llagas Creek are largely located in this younger alluvium. For the whole watershed, 51 percent of the land is considered suitable for cultivation, with 39 percent within Classes I and II.

Climate in the Llagas Creek area is typical of the Central California coastal valleys with warm dry summers and cool wet winters. Mean annual precipitation, almost entirely in the form of rain, varies between 19 inches in the valley area near the mouth of Llagas Creek and 40 inches near the summit of Mt. Chuai. About 76 percent of the mean annual rainfall occurs between December 1 and March 31, and 92 percent between November 1 and April 30. Mean annual temperature is 58°F, with a monthly variation between 66°F in July and 48°F in January. Extreme temperatures in Gilroy have varied between a low of 20°F and a high of 116°F. The average frost free period is 273 days.

Economic Data

Historically, agriculture has been the major industry in the project area. Even with today's trend toward urbanization, the growing, processing, and marketing of farm products accounts for about 60 percent of the annual income; and 20 years from now agriculture will remain the predominant land use as it is expected to still occupy 73 percent of the flood plain. The valley land north of Gilroy is predominantly devoted to prune orchards with smaller areas in strawberries, grains, and hay. South of Gilroy such vegetable crops as sugar beets, beans, garlic, tomatoes, and lettuce predominate. Many walnut orchards are located along Llagas Creek in the upper watershed. Most of the lands described above are irrigated by pumped groundwater. Poultry and cattle raising are quite extensive along the valley fringes.

The non-agricultural sector of the area's economy is divided between manufacturing and commerce. Metal products manufacturing is an important industry, with the largest factory making earth-moving equipment. Commerce consists of the trade generated by the local population and traffic on U. S. Highway 101. An important factor in this segment of the local economy is the growing number of people who live within the watershed but commute to a place of employment in the San Jose area.

Urban development is expected to continue at an accelerating pace. By 1985 urban development is expected to increase from its present 3 percent of the flood plain area to about 27 percent. According to the Santa Clara County Planning Commission, watershed population is expected to increase from the present 9,000 to about 100,000 by the year 2000. Forecasts made by the U. S. Department of Commerce and the California Department of Water Resources look for even greater amounts of urban development. While it is impossible to predict specific locations, relative amounts of the different types of urban development have been forecast by the County Planning Commission.

All the urban and a great majority of the highly developed agricultural land within the watershed is concentrated on the valley floor, while the larger land holdings with a lower type of land use are found in the upper watershed. The present state of land development can be categorized as follows:

Land Use	Acres	Percent
Urban	496	1.4
Orchard	7,239	20.9
Row crops	1,873	5.4
Hay	949	2.7
Irrigated pasture	2,220	6.4
Other pasture and range land	15,586	45.1
Forest and brush land	6,053	17.5
Miscellaneous	205	0.6
Total	34,621	100.0

At the present time, the urban development within the watershed is concentrated along and closely parallel to the Southern Pacific Railroad and U. S. Highway 101 which run along the west side of the valley floor. The unincorporated town of San Martin, with a population of 1,200, lies entirely within the watershed. Nearby incorporated cities include Morgan Hill, with a population of 3,200, just north of the watershed boundary, and Gilroy, with a population of 7,400, located partially within the watershed along its southwest boundary.

All three towns draw much of their trade from traffic on U. S. Highway 101 along which they possess a commercial strip development. Industrial development is concentrated along the railroad on the east edge of each town, and the residential areas are predominantly west of both the highway and the railroad. In addition to serving as trading centers for their surrounding agricultural areas, the towns contain food processing plants for such products as pickles, wine, health products, garlic, and strawberries, and there is some metal products manufacturing in Gilroy.

In addition to its highway and railroad connections on U. S. Highway 101 and the Southern Pacific Railroad, which place it on the main traffic line between San Francisco and Los Angeles, the watershed

is traversed by State Highway 152 which connects Gilroy with the Monterey Bay area to the west and the San Joaquin Valley to the east. Within the valley area exists an excellent network of all-weather roads serving both agricultural and urban areas. However, in the upper watershed the all-weather road following along Llagas Creek has very few feeder roads providing access to the brush and range land.

Of the total watershed population, estimated at 9,000 from the 1960 census, about 3,500 live on nearly 900 separate farm units, most of which are owner operated. About 60 percent of these farms are in the flood plain area.

Land values within agricultural areas range from $160 per acre for brushland to $7,000 per acre for the best orchard areas. Average per acre values for the various types of land found within the watershed include $500 for rangeland, $1,300 for row crop land, and $3,300 for orchard land. Since the average annual net farm income per acre ranges from $8 for grain to $475 for strawberries, with an over-all average of $70, it should be noted that the pressure of urban expansion from the San Jose area to the north is increasing land values far beyond their agricultural worth.

Urban land values range from a low of $2,500 per acre in the more isolated areas to a high of $8,000 near the city of Gilroy. Inside Gilroy some lands are valued at $100 per frontal foot. An over-all average value for urban land in the watershed is in the neighborhood of $4,000 per acre.

Farms within the watershed range in size from 5 to 3,200 acres, with an average of 18 acres in the flood plain and 74 acres in the upper watershed. Within the area subject to flooding, no farm units exceed 50 acres. All land within the watershed is non-federally owned.

WATERSHED PROBLEMS

Floodwater Damage

Floodwaters originating within the Llagas Watershed inundate up to 9,800 acres once every 100 years on a long-term average with smaller acreages flooded at more frequent intervals. The present value of land, improvements, and other property within this area is $48,500,000, and conservative estimates indicate an increase to $234,000,000 by 1985. This flood hazard area includes more than half of the valley floor and is equivalent to roughly 28 percent of the entire watershed.

Agricultural damages associated with flooding include a reduction in crop yields or, in some cases, even total crop losses, forced delays in planting due to wet field conditions, the induction of additional weed growth and washing of debris necessitating field clean-up operations, and induced plant diseases and rot. Urban damages consist of cleaning up, repairing, or replacing those items within buildings and on their

surrounding grounds that have come in direct contact with floodwaters. Additional damages have been inflicted to public transportation facilities; such as roads and railroads, farm buildings and machinery, and irrigation systems. Interruption of communication and public utility services and the general disruption of the areal economy are less tangible damages.

Some flooding occurs four years out of every five, but the greatest part of the average annual damages is associated with the major flooding that occurs about one year out of every five. Three out of every four major floods occur in the winter months of December, January, and February, and the remaining ones come in March and April. Ten of these major floods have occurred since 1909, with the two most recent years being 1955 and 1958. Since these floods are recent enough to obtain reliable data and are typical of the major floods within the watershed, it is helpful to the understanding of the flood problem to describe the flood damages associated with one of them in greater detail.

After almost continuous heavy rainfall for a period of one week, a large flood peak was reached on Llagas Creek on December 23, 1955. Before the floodwaters receded, over 4,500 acres had been inundated; and severe loss was sustained by the flooding and prolonged inundation of garlic and lettuce fields. Homes, farm equipment, roads, and bridges were damaged in rural areas. In Gilroy 16 city blocks were inundated along Miller Slough, and 225 people were forced to leave their homes for a two day period. Eighty-six of these were provided mass shelter by the Red Cross.

As high as historical flood damages have been, they fall far short of those that would occur during future floods of similar magnitude. Urban development within the watershed is expected to increase to eight times its present level within the next 20 years. Furthermore, technological progress is constantly increasing the quality and, hence, the value of urban construction. Thus, in the absence of protective measures, these factors will combine to raise future flood damages to many times their historical values.

Sediment Damage

Damages ascribable to sedimentation are not easily separable from those due to floodwater. Damages to truck crops due to a thin film of silt left by muddy overwash occur after flooding, and the deposition of a relatively thin layer of debris on garlic fields occasionally prevents the emergence of the plants. Little of the damages sustained by orchard trees is directly attributable to sedimentation, although usually some clean up is required. Streambed aggradation is not a problem in the watershed. Although some natural levees have been built by the streams, large-scale overbank deposition is not widespread.

Sediment damage to urban areas is of a similar type as that to agricultural areas. Relatively thin deposits of silt are left by the retreating floodwaters on the floors of homes, in basements, and on lawns and gardens.

Erosion Damage

Accelerated erosion and hence critical sediment source areas are not pronounced in the Llagas Creek Watershed. Under present watershed cover conditions, sheet, rill, and gully erosion are not serious, although an extensive wildfire could increase many times sediment production from these sources. Several isolated instances of bank erosion and minor land loss were noted but none of large magnitude. Most of this erosion is due to bends in the stream or eddies caused by obstructions. Most of the channels in the watershed currently have well-vegetated banks.

PROJECTS OF OTHER AGENCIES

In order to alleviate a growing ground water shortage brought on primarily by heavy pumping of irrigation water, the South Santa Clara Valley Water Conservation District built 7,630 acre-foot Chesbro Reservoir on Llagas Creek in 1955. The reservoir functions by holding back runoff and then releasing water downstream slowly enough so that the entire amount can percolate into the ground. The primary percolation area on Llagas Creek is the 19,000 foot reach between U. S. Highway 101 and Masten Avenue. In 1958 the district built 10,350 acre-foot Uvas Reservoir on nearby Uvas Creek and a 36-inch pipe to import Uvas water into the Llagas Watershed and thus further supplement their suppy of recharge water. Even though these two reservoirs have been highly successful in achieving the desired objective of supplementing ground water recharge, the sponsors have expressed no desire to develop additional agricultural water at this time because they are presently contracted to purchase imported water. Special care has been taken to insure that channel improvement proposed within this plan does not materially affect the functioning of the percolation beds.

The Santa Clara County Flood Control and Water Conservation District is currently constructing and expects to have completed in 1962 a flood channel known as the Princevalle drain along the south city limits of Gilroy. Provision is made for this drain to empty into Llagas Creek where Miller Slough presently enters. This improvement will have no significant effect on flood damages within the area benefited by this work plan.

The U. S. Army Corps of Engineers has an active investigation on the Soap Lake and Pajaro River area downstream from the mouth of Llagas Creek. Already constructed are flood control levees along the Pajaro River in the vicinity of Watsonville. The inclusion of flood control storage within Chesbro Reservoir offsets any adverse effects channelization will have on downstream flood peaks according to hydrological studies made in conjunction with this work plan. The Corps was consulted in the preparation of this work plan.

Considerable land treatment, including both on farm and fire protection measures, has been applied to the watershed. Quantities and estimated values of these various measures are found on Table 1A. Land treatment has been installed on the farms by the landowners with technical assistance from Soil Conservation Service personnel. Fire protection is

provided for 16,000 acres in the upper watershed by the California Division of Forestry. Fire stations are located at Morgan Hill on Little Llagas Creek and near Los Gatos northwest of the Llagas Watershed.

BASIS FOR PROJECT FORMULATION

The objective of this project is to formulate a solution to the existing flooding problem including the related aspects of sedimentation and erosion. The project area selected is the largest hydrologic unit within which this objective can be reached within the scope of Public Law 566. While additional objectives, such as water management and fish and wildlife enhancement, were considered, local support could not be found. Local interests recently contracted to augment their water supply with imported water.

Because urban expansion is imminent throughout the project area and the California Soil Conservation Commission specifies a minimum level of protection for urban areas, all structural works of improvement are designed to protect against a flood of such magnitude that it has only one chance in a hundred of occurring in any given year. There is no area within the flood plain where urban development is not probable within the next 20 years.

Every effort was made to coordinate all structural works contemplated within this work plan with other existing or proposed projects within or near the project area in order to assure the full development of the soil and water resources. The measures proposed will not adversely affect and, in some cases, will actually enhance these other projects.

Special care was taken to insure coordination between this work plan and the channel improvements that are expected to be soon constructed to alleviate the flood problem in the tributary Little Llagas Watershed. An application has been submitted for this watershed, and it is anticipated that a separate work plan will follow within the next two years. Provision has been made to size and locate channel improvements on Llagas Creek in such a manner as to not preclude optimum flood prevention measures in the Little Llagas Watershed, and it has been further found that failing to install the needed improvements on Little Llagas will not adversely affect any of the structural measures proposed in this work plan.

The sizing and locating of structural measures were based on providing the maximum net flood protection benefit consistent with the chosen level of protection. In the cases of proportioning between flood detention storage and channel improvement, selecting channel alignment, and investigating various diversion schemes, project formulation involved detailed cost studies to ascertain the relative merit of numerous alternative proposals. In each case the proposal included within the work plan represents the best of these proposals within estimating accuracy.

The kinds of measures selected for achieving the project objective represent the optimum method for alleviating the flood problems. Providing flood detention storage reduces peak flood flows by holding back

runoff from the upper watershed. Channel improvement work increases the ability of the channels to contain these flows and to resist bank erosion. Intensified fire prevention and other land treatment measures are included where they are found to make a definite contribution to problem solution through the reduction of runoff, erosion, or sediment transport. The project as formulated thus represents the best means available for fulfilling the desires of the sponsoring local organizations based on the experience, investigations, and technical knowledge of the various Federal, State, and local agencies consulted in the preparation of this report.

WORKS OF IMPROVEMENT TO BE INSTALLED

Kinds and amounts of land treatment measures specified herein represent estimates of the need based upon land capabilities and land use, adjusted to the rate of application expected to result from assignment of an optimum technical staff to the Soil Conservation District.

Structural measures are prescribed on the basis of an investigation made in sufficient detail to establish locations and feasibility. After work plan approval, further studies will be made to supply the details that will be necessary in preparation of construction plans and specifications. These studies may dictate alterations within the current scope and in accordance with Technical standards of the Service and the desires of the sponsoring groups.

Land Treatment Measures

A basic element in the selection of land treatment measures for this work plan was to include only those measures which would have a measurable effect upon the production of floodwater or sediment or would in some way complement the effectiveness of the proposed structural measures. Most of the proposed on-farm land treatment measures serve to enhance the vegetative cover. The cover in turn decreases runoff by increasing rainfall interception and decreases erosion by reducing the direct exposure of the soil to rainfall impact and running water. Measures in this category are those involving seeding, planting, fertilizing, and properly using crop and range areas. Other land treatment measures involve improvements, such as grassed waterways, stream bank protection, grade stabilization structures, and erosion control structures, which directly reduce sediment production. Field ditches and diversions serve to reduce floodwater damages. Other land treatment on the valley floor area, such as land leveling and improved water application, serves to insure proper use of agricultural land so that the benefits calculated in this plan can be realized. While many land treatment measures are presently being installed, the rate of installation will have to be greatly accelerated to reach the required amounts by the time the installation of structural measures is completed. The amount of the measures to be installed during the project period and the estimated costs are found on Table 1. Cooperative agreements between the Soil Conservation District and individual farmers will include the land treatment measures agreed upon for application and will be consummated prior to project completion. Planning and installation costs, including $44,100 of Public Law 566 funds for accelerated technical assistance and $342,400 of other funds, amount to $386,500.

Additional land treatment measures consist of augmenting the present fire control program to reduce the average annual burn rate from 1.88 percent to 0.75 percent over a 16,000 acre area in the upper watershed. Specific measures are located on the project map, and a detailed cost breakdown is found on Table 1. The program will be effected by the construction of 24.1 miles of road traversable with 4-wheel drive equipment, 1.8 miles of road passable with conventional drive equipment, 19.9 miles of firebreak of widths from 75 to 100 feet, 6 miles of firebreak less than 75 feet wide, 12 helispots, and three 10,000 gallon water tanks installed at strategic locations. Rights-of-way and technical assistance are also provided. Total cost for fire control measures include $80,840 from Public Law 566 funds and $144,460 from other funds, for a total of $225,300.

Structural Measures

The plan for structural measures within the watershed includes raising Chesbro Reservoir to provide 3,570 acre-feet of flood control storage and constructing 20.6 miles of improved or realigned channels to sufficient capacity to contain the attenuated 1 percent flood.

The locations of these measures are shown on the project map, and structural plans are near the back of the work plan. Cost breakdowns for each measure are in Table 2; and other pertinent data, dimensions, and capacities are in Table 3.

The existing homogeneous earth dam will be raised 11 feet to a new total height of 116 feet above the preconstruction streambed. This will add 3,570 acre-feet of floodwater detention to the existing reservoir's 110 acre-feet of sediment storage and 7,520 acre-feet of conservation storage to bring the total storage in the reservoir to 11,200 acre-feet. The present sediment reservation will still be sufficient after raising is completed, and no change will be made in the conservation storage. The drainage area above the reservoir is 18.9 square miles or roughly 24 percent of the area tributary to the Llagas Creek Project. The provided floodwater detention will be sufficient to reduce flood peaks on lower Llagas Creek by about 10 percent. The emergency spillway crest will be 80 feet wide with a 25 foot by 12 foot deep notch centered therein to serve as the principal spillway. This combination spillway will discharge 2,910 cubic feet per second with the water surface at the elevation of the emergency spillway crest and 11,000 cubic feet per second during the freeboard flood. The existing chute, capacity 11,000 cubic feet per second, discharges into Llagas Creek immediately downstream from the dam. The total estimated installation cost for raising Chesbro Dam is $1,092,500.

Channel improvement work on Llagas Creek will consist of improving and straightening 10.8 miles of existing channel along substantially the present alignment. Of this distance 8.0 miles are in noncohesive soils requiring riprap protection on the channel banks, and the remaining 2.8 miles are in cohesive soil allowing earth channels with vegetated banks. In addition, 1.3 miles of channel opposite San Martin presently have sufficient capacity but will be maintained as part of this project to insure integrated operation and maintenance of the entire flood channel system. The approximately five miles of channel between Chesbro

Reservoir and the upstream limit of the proposed works of improvement have adequate capacity to handle the 1 percent outflow from the raised reservoir. Proposed channel sections will range in capacities from 3,430 to 16,140 cubic feet per second, in bottom widths from 42 to 182 feet, and in depth from 7 to 15 feet. Maximum velocities will reach 7.9 feet per second for the earth channel and 8.8 feet per second for the rocked channel. Ten drop structures are included to stabilize the proposed channel grade and thus prevent extensive erosion on Llagas Creek. In addition, drop structures will be provided on Live Oak and Panther Creeks to bring their bottom elevations down to the proposed Llagas Creek grade at the point of junction. These channel improvements on Llagas Creek will alleviate much of the present flood problem by providing a trunk channel with adequate capacity to drain the tributary area. Installation cost for channel improvement work on Llagas Creek will be $4,161,000.

An additional 9.8 miles of channel improvement work will be required to carry floodwaters originating in the Miller Slough-West Branch Llagas area to Llagas Creek. All these channels will be unlined with vegetated banks as they will be located entirely in cohesive soils. These channels will substantially follow existing water courses in their upper reaches. However, the majority of West Branch Llagas flows will be diverted directly eastward into Llagas Creek along Day Road about two miles north of Gilroy to avoid costly channel improvement work through the downtown area. This diversion will have two smaller feeder channels to intercept flood flows from the north and west. Proposed channel sections for this system will range in capacities from 1,060 to 3,900 cubic feet per second, in bottom widths from 8 to 45 feet, in depths from 4 to 13 feet, and have velocities reaching 6.8 feet per second. Downstream from this diversion additional channel work is required on Miller Slough. This improvement will consist of reshaping and slightly enlarging the existing channel section through Gilroy, providing three feeder channels to collect the flood flows, and realigning the downstream portion to join Llagas Creek a little more than a mile upstream from the present junction. Proposed channel sections for this system will range in capacities from 160 to 3,220 cubic feet per second, in bottom widths from 4 to 60 feet, in depths from 4 to 15 feet, and have velocities reaching 5.7 feet per second. Seven drop structures are provided in these two systems to reduce velocities to allowable limits for the soils. The channel improvements in both systems will serve to alleviate the present flood problem in Gilroy by providing adequate channels to carry floodwaters originating in this area to Llagas Creek. Installation cost will be $2,064,000.

An installation cost item of $20,000 is included to provide for the geologic exploration required to evaluate the various potential riprap sources. This is a design stage item to be expended prior to completion of the first final plans and specifications so that type and costs of riprap can be better evaluated.

EXPLANATION OF INSTALLATION COSTS

Land Treatment Measures

Costs for land treatment for which the Soil Conservation Service will have the technical responsibility as found on Table 1 are based on the estimated quantity-unit cost approach and total $386,500. Of this total, $325,800 represents the cost of physically applying the required measures and will be met by the landowner on whose property the measure is required. Technical assistance will be met from Soil Conservation Service funds, with $16,600 representing expenditure of normal operating funds for the going rate of application and $44,100 being contributed from Public Law 566 funds for accelerating the application rate.

Installation costs of the planned land treatment measures excluding intensified fire protection are estimated by years as follows:

Fiscal Year	P.L. 566 Funds (Dollars)	Other Funds (Dollars)	Total (Dollars)
1	0	5,100	5,100
2	8,800	34,300	43,100
3	8,900	46,200	55,100
4	8,800	85,600	94,400
5	8,800	85,600	94,400
6	8,800	85,600	94,400
Total	44,100	342,400	386,500

Costs for land treatment in which the Forest Service will participate are also based on quantities and unit costs with a percentage increase to provide for technical assistance to give a total installation cost, exclusive of rights-of-way and easements, of $161,680. Of this total, 50 percent or $80,840 will be borne by Public Law 566 funds, and the remainder will be borne by the sponsors with the understanding that they may qualify for assistance from the State of California amounting to some portion of their responsibility. An additional cost of $63,620 is estimated for rights-of-way and easements and will be borne by the local sponsors. This can be accomplished either through the raising of funds by the sponsoring agencies or by direct donation by the landowners involved. Installation of fire control measures will be accomplished over the first five years of the six year period used in constructing other measures according to the following schedule by fiscal years:

First year

Obtain all rights-of-way required for fire control measures.

Construct or improve 7.2 miles of 4-wheel drive road, 3 miles of 75 feet to 150 feet firebreak, 3.9 miles of 75 feet firebreak, and 6 helispots on the north boundary of the watershed project.

Second Year

Construct 11.3 miles of 4-wheel drive road, 11.3 miles of 75 feet to 150 feet firebreak, and 5 helispots along the south boundary of the watershed project.

Third Year

Construct 5.6 miles of 4-wheel drive road, 5.6 miles of 75 feet to 150 feet firebreak, 2.1 miles of 75 feet firebreak, and 1 helispot.

Fourth Year

Construct 1.8 miles of medium standard conventional road.

Fifth Year

Construct three 10,000 gallon water storage tanks.

Installation cost of the planned fire control measures are estimated by years as follows:

Fiscal Year	P.L. 566 Funds (Dollars)	Other Funds (Dollars)	Total (Dollars)
1	20,260	83,880	104,140
2	23,960	23,960	47,920
3	15,040	15,040	30,080
4	20,710	20,710	41,420
5	870	870	1,740
Total	80,840	144,460	225,300

Structural Measures

The estimated cost of structural measures found on Table 2 is based on quantities calculated as part of the engineering design. The construction cost was determined by multiplying these quantities by unit cost averaged from bid prices within the area and adding a 15 percent contingency factor. This factor is considered adequate because of the detailed surveys, geologic exploration, and design work completed for quantity determination. Engineering costs are estimated as 17 percent of the construction cost; and in developing costs for the construction schedule, 12 percent is figured to occur in the year preceding construction and 5 percent during the construction year. In the case of Chesbro Reservoir an additional cost of $5,000 for hydraulic model studies for the detailed design of the spillway is included in the engineering cost and will occur the year prior to construction. An additional $20,000 is also provided for the geologic exploration required in evaluating potential riprap sites and will be spent the first fiscal year. Other Federal installation service costs equaling about 5.5 percent of the construction costs are included during the year of construction. The above costs total $4,699,100 and will be met from Public Law 566 funds.

Other installation costs include obtaining rights-of-way and easements, relocating or rebuilding bridges, roads, and other utilities, and local administrative cost. The total costs of $1,209,500 associated with obtaining land and $1,369,000 associated with relocating facilities will be met by the sponsoring organizations, but they in turn may be reimbursed by the State of California for all or a portion of these funds. Local administrative costs amounting to $45,000 for the administration of contracts and State dam filing fees will be borne entirely by the sponsoring agencies.

An additional construction cost of $14,900 associated with revising the outlet works for Chesbro Reservoir will be borne by the sponsors, again subject to reimbursement by the State of California. The total installation cost of this facility, amounting to $28,500, is subject to cost sharing as the relocation of an existing agricultural water management facility, with the Federal share not to exceed 46 percent. As the ratio of secondary benefits to total benefits exceeds this percentage, it will be the Public Law 566 share. Therefore, Public Law 566 funds will provide $13,100 or 46 percent of this cost, and the sponsors will provide $15,400 or 54 percent. The Federal share includes 35.2 percent of the construction cost ($8,100) and all costs for installation services ($5,000) while the local share includes the remaining 64.8 percent of the construction cost ($14,900) and all costs for contract administration and State dam filing fees ($500). Except for the local share of the construction cost, all the other above costs are included in the total costs found previously in this section.

The installation of structural measures will be accomplished over a six year project period in accordance with the following schedule by fiscal years:

First Year

Geologic exploration to locate a suitable source for rock riprap.

Preparation of designs and specifications and acquisitions of rights-of-way for channel improvements on Llagas Creek from the lower limit of the project upstream to the proposed junction with Miller Slough.

Second Year

Construction of Llagas Creek channel improvements from the lower limit of the project upstream to the proposed junction with Miller Slough.

Preparation of designs and specifications and acquisitions of rights-of-way for channel improvements on Llagas Creek from the proposed junction with Miller Slough upstream to the proposed West Branch Llagas Diversion.

Third Year

Preparation of designs and specifications and acquisitions of rights-of-way for the raising of Chesbro Dam and the associated highway relocation.

Construction of Llagas Creek channel improvements from the proposed junction with Miller Slough upstream to the proposed West Branch Llagas Diversion.

Fourth Year

Construction work on Chesbro Dam and necessary road relocation.

Preparation of designs and specifications and acquisitions of rights-of-way for channel improvement work on Miller Slough, the West Branch Llagas Diversion, and their tributary channels.

Fifth Year

Construction of channel improvement work on Miller Slough, the West Branch Llagas Diversion, and their tributary channels.

Preparation of designs and specifications and acquisition of rights-of-way for channel improvements on Llagas Creek upstream from the proposed West Branch Llagas Diversion.

Sixth Year

Construction of Llagas Creek channel improvements upstream from the proposed West Branch Llagas Diversion.

Estimated total expenditures by years are as follows:

Fiscal Year	P.L. 566 Funds (Dollars)	Other Funds (Dollars)	Total (Dollars)
1	100,000	132,000	232,000
2	850,000	289,000	1,139,000
3	1,095,000	325,500	1,420,500
4	559,100	984,900	1,544,000
5	1,041,000	834,000	1,875,000
6	1,054,000	73,000	1,127,000
Total	4,699,100	2,638,400	7,337,500

EFFECTS OF WORKS OF IMPROVEMENT

The primary effect of the measures proposed within this work plan is to reduce the flooding that otherwise would be expected to cause average annual damages of $689,500 over a 9,800 acre area to such small amounts that residual damages are almost nonexistent. While some flooding presently occurs four years out of every five, with the proposed measures flooding will be associated only with events exceeding that occurring one year out of every hundred on a long-term average, and even this flooding will be reduced in amount.

Presently the flood plain is distributed into approximately 1,000 ownerships, about half of which are agricultural and half of which are urban. Within the next 20 years total landowners should multiply to about seven times this number. Counting residents of urban areas, total direct beneficiaries now living in the flood plain amount to about 4,500 people. Additional direct beneficiaries are found among owners of the industrial and commercial concerns that may be flooded.

Land treatment measures will be effective in reducing sediment production and floodwater runoff. Based on a fire control program reducing the average annual burn rate in the upper watershed from 1.88 percent to 0.75 percent, sediment production will be reduced by about 10 percent in the area where this program is applied. In the flood plain area this will effect about a 2 percent reduction in sediment deposition. The decrease in runoff ranges from a 2 percent reduction in flood peaks on the 1 percent hydrographs up to roughly a 10 percent reduction in flood peaks on annual storms. These reductions in sediment production and flood peaks will, of course, have some beneficial effects in the area downstream from the Llagas Watershed.

Special care was taken in the design of structural measures to prevent any detrimental effects in areas downstream from the proposed structural measures. The tendency of better channelization to increase flood peaks is offset by the reduction effected by providing flood detention storage for floods of all magnitudes.

The principal beneficial effect outside the watershed of the proposed works of improvement results from the fact that floodwaters from Llagas Creek will no longer break over into the Little Llagas and Alamias Watersheds inundating large areas and causing extensive damage. In the case of Little Llagas, further benefit will be realized by providing a good outlet into Llagas Creek so that floodwaters will no longer be backed up over large areas. During a flood of the magnitude used in designing the structural measures, approximately 1,000 acres of the total 2,800 acres flooded within the Little Llagas Watershed can be directly attributed to Llagas Creek waters; however, these waters only cross into this other watershed about one year in ten on a long-term average. The benefits associated with preventing this flooding are integrated into the benefits for the Llagas Creek economic evaluation unit and thus included as part of the project justification.

This plan will have minor influence on wildlife resources. The reduction of small game that may result where channel improvements will destroy natural habitat will be mitigated by retaining plant growth on

channel banks and levees wherever possible and by planting wildlife food and cover along new banks and levees where feasible. Care will be used in channel maintenance to avoid use of materials toxic to fish and wildlife.

PROJECT BENEFITS

The total average annual evaluated damage caused by floodwaters originating within the watershed amounts to $689,500. This figure includes direct and indirect damages associated with floodwater and sediment in both agricultural and urban areas. Land treatment measures are expected to reduce flood damages by $54,100 annually to leave remaining damages at $635,400. Because all evaluated damages will be practically eliminated by project measures, benefits to be matched against structural measures equal $635,400 and accrue from eliminating those primary damages described previously under watershed problems. Allocating these benefits to their respective evaluation units gives annual values of $150,200 for the West Branch Llagas Creek unit and $485,200 for the Llagas Creek unit.

Evaluated benefits associated with land treatment measures consist of a reduction in flood damages. Both the on-farm and the fire control measures enhance cover conditions in the upper watershed and thus reduce sediment and floodwater production.

Unevaluated primary benefits are associated with the reduction of damages to farm buildings and property, agricultural equipment, and such public facilities as roads and utilities. Additional primary benefits associated with the fire control program include the reduction of sediment deposition in Chesbro Reservoir, savings in fire suppression costs, and lessening direct fire damage to property. Other unevaluated benefits include a reduction in service interruptions on major communication and transportation facilities as well as such public utilities as gas, water, sewage, and power lines. Interruption of these facilities affects numerous users and, in the case of the highway and railroad lines between San Francisco and Los Angeles, would be extremely dangerous during a national emergency.

Secondary benefits are quite significant but not subject to rigorous monetary evaluation. A general increase in the level of economic activity will also develop as a result of the great reduction in the threat of flooding. Increased economic activity in any area raises local purchasing power and hence enhances national economic growth. Additional secondary benefits stem from a reduction of the danger to public health wrought by the presence of floodwaters. Included in this category are the contamination of wells, induced insect breeding, and the disruption of sanitation facilities.

COMPARISON OF BENEFITS AND COSTS

Benefits and costs for each evaluation unit as well as the project as a whole are tabulated and compared on Table 6. Benefits divided by costs are shown to be 2.7 for the West Branch Llagas Creek unit and 2.0 for the Llagas Creek unit. For all proposed structural measures the benefit-cost ratio is 2.1 to 1.0.

PROJECT INSTALLATION

All the measures proposed within this work plan will be installed according to the schedules previously presented and divided into costs by fiscal years over the six year installation period. The schedule for structural measures shows some construction beginning previous to obtaining total project rights-of-way. This procedure is made possible by the fact that the Santa Clara County Flood Control and Water Conservation District has legal authority to exercise the power of eminent domain and with reimbursement from the State of California sufficient funds to purchase the required land. The District is aware of its responsibility in this regard and will use its authority and funds as necessary. All rights-of-way for the fire control program will be secured prior to commencing construction.

Each of the sponsoring agencies has and recognizes its definite responsibilities in accomplishing the plan. The Santa Clara County Flood Control and Water Conservation District will acquire or purchase all required rights-of-way and make all the required utility relocations and modifications amounting to an estimated total cost of $2,578,500 for structural measures and may be reimbursed in turn for all or part of this amount by the State of California. In addition, the District will be responsible and may be reimbursed for 64.8 percent of the construction cost of altering the outlet facilities on Chesbro Dam at an estimated cost of $14,900. It will also let and administer all construction contracts involved in constructing structural measures and pay the State dam filing fees at a cost of $45,000. All structural measures required in this project will be constructed by a contractor selected by competitive bidding. In addition, the District will be responsible for the local share of the installation cost for fire control measures amounting to $80,840 and obtaining the required rights-of-way valued at $63,620. However, these costs may be substantially reduced through land donations and aid from the State Division of Forestry, which will also provide the required technical assistance in formulating and installing the fire control measures. The South Santa Clara Valley Water Conservation District will take an active part in the raising of Chesbro Reservoir and channel installation in the percolation bed area but will have no direct financial responsibility other than that which may be evolved through agreement with the Flood Control District. The Loma Prieta Soil Conservation District will actively encourage installation of on-farm land treatment measures and make sure the sign up of landowners as district cooperators meets the Public Law 566 requirements. Landowners will spend $325,800 individually or in small groups installing these measures during the installation period.

The U. S. Forest Service and the California State Forester have entered into a cooperative agreement providing for joint responsibility in planning and executing land treatment measures under Public Law 566. Therein the State Forester has agreed to arrange for the installation of fire protection measures on non-Federal forest lands as specified in watershed work plans. To implement this responsibility, the State Director of Conservation, through the State Division of Forestry, will enter into agreements with the local interests concerned; in this case,

the Santa Clara County Flood Control and Water Conservation District. Under this type of agreement, the District may either elect to install the required measures with its own forces or to do it through or jointly with the Division of Forestry.

The evacuation of Chesbro Reservoir for construction of the raised dam and associated facilities will not result in any serious loss of usable water. Since this reservoir and Uvas Reservoir are operated conjunctively with the ground water basin for the Llagas Creek service area, the water evacuated can be transferred to the ground water basin and the normal storage requirements at Uvas can be increased. Chesbro Reservoir is not designed for a long carry-over period.

The Soil Conservation Service will contribute from Public Law 566 funds 100 percent of the construction cost for stream channel improvements, estimated at $3,399,000; 100 percent of the construction cost for raising Chesbro Dam, estimated at $406,000; 35.2 percent of the construction cost for revising the outlet works at Chesbro Dam, estimated at $8,100; and 50 percent of the installation cost exclusive of rights-of-way and easements for intensified fire prevention measures, estimated at $80,840. In addition to providing for the payment of all or cost sharing in the contract cost of construction as established by competitive bidding on the above items, the Service will also bear the engineering costs involved in preparing the contract plans and specifications for the structural measures and in supervising and inspecting construction, estimated at $676,000; the costs associated with certain technical and legal review of the project, estimated at $210,000; and the cost of technical assistance for the accelerated application of on-farm land treatment measures, estimated at $44,100. Total expenditures from Public Law 566 funds will thus amount to $4,824,040 over a six year period. The Service will also provide $16,600 from its normal operating funds to continue the going program of technical assistance for developing proper farm plans and designing land treatment measures through the installation period.

FINANCING PROJECT INSTALLATION

The Santa Clara County Flood Control and Water Conservation District has manifestly proved its financial capability to meet its enumerated obligations through the numerous channel improvement measures it has constructed in the northern part of the county. The South Santa Clara Valley Water Conservation District has spent approximately $1,900,000 in developing water conservation on Uvas and Llagas Creeks. However, of the $189,460 that the sponsors are obligated for and that is not subject to reimbursement by the State of California, only the $45,000 for the administration of contracts and State dam filing fees will be met immediately from local funds. The local share of the fire control program cost may be raised through negotiating a loan from the U. S. Farmers Home Administration for an amount up to $144,460. Negotiations are under way and a letter of intent was filed with the State Director of Farmers Home Administration to seek this credit. No other credit is presently being sought by the sponsoring agencies.

The State of California, Department of Water Resources, will be contacted by the sponsors regarding reimbursement to the County of the $2,593,400 associated with acquiring right-of-way and facility relocation. The Department has been kept informed of the progress of project formulation and is prepared to meet this obligation subject to its detailed review of the project. In addition, the State may also contribute through the Division of Forestry a portion of the $144,460 required for fire control measures.

While it is possible that once installation begins certain easements or rights-of-way may be obtained by donation from the present owner, no allowance was made for this event in estimating the costs. Such donations would thus merely serve to reduce the financial obligation of the State or local agency involved.

The individual sponsoring organizations recognize their total financial obligation and the timing shown in the installation schedule and are ready as outlined above to meet this obligation through local tax funds, credit from the U. S. Farmers Home Administration, and State reimbursement. These organizations are also aware that the financial and other assistance to be furnished by the U. S. Soil Conservation Service is conditioned on the fulfillment of the local obligation presented in this plan and contingent on congressional appropriation of the required funds.

While the land treatment measures for watershed protection will be installed on private property by individuals or small groups of landowners, the financial obligation may be met in part through Federal cost sharing in the U. S. Agricultural Conservation Program and through credit provided by the regular loaning facilities of the U. S. Farmers Home Administration.

PROVISIONS FOR OPERATION AND MAINTENANCE

Operation and maintenance of on-farm land treatment measures will be the responsibility of the individual landowners on whose property the measure is located. The Loma Prieta Soil Conservation District and the Soil Conservation Service will provide the technical advice and periodic inspections necessary to insure that the measures are being properly maintained.

The California Division of Forestry has estimated an average annual operation and maintenance cost of $1,800 for the intensified fire prevention phase of the land treatment program. These measures will be operated and maintained either directly by the Santa Clara County Flood Control and Water Conservation District in whom the responsibility rests, or indirectly by local fire protection agencies under agreement with the District. In addition to maintaining the installed measures proposed in Table 1, to insure their continuous readiness for use during fire fighting, proper fire control maintenance includes the prompt emergency treatment of burns on those areas that would produce accelerated erosion, debris production, or sedimentation problems. For such emergency treatment, State or Federal funds are usually available to assist in watershed restoration.

Operation and maintenance of the flood control facilities at Chesbro Dam and Reservoir will be the financial responsibility of the Santa Clara County Flood Control and Water Conservation District, but the actual work may be delegated to the South Santa Clara Valley Water Conservation District, the agency presently operating this facility. An average annual cost of $2,300 has been estimated to represent the additional expenditure for this work. Operation and maintenance work attributable to raising the dam will include such things as repairs to the concrete structures proposed in the vicinity of the spillway crest, removing and burning floating debris in the reservoir, and maintaining the face of the raised dam. The Flood Control District will be able to finance this maintenance work by tax revenue sources presently developed.

All channel improvement work proposed in this plan will be operated and maintained by the Santa Clara County Flood Control and Water Conservation District at an estimated average annual expenditure of $35,700. The District is presently operating numerous flood channels elsewhere in the county by use of tax revenues and is financially able to expand its program into the watershed. The estimated cost includes allowances for the materials, labor, equipment, and overhead associated with such channel maintenance work as weed and brush control, rodent control, after flood clean up, and structural repair to riprap and concrete structures. Maintenance roadways are provided along all improved channels and for the 7,000 feet of unimproved channel on Llagas Creek opposite San Martin that will be maintained as part of this project, except that for limited areas on Miller Slough within Gilroy access to the channel will have to be along private roads. In these cases the District will obtain right-of-entry agreements from the owner involved prior to channel construction. The South Santa Clara Valley Water Conservation District may share operating responsibilities for those flood channels through their present percolation area.

Inspection of all completed works of improvement will be conducted twice annually and after each major flood. Interim and spring inspections will be made to ascertain what maintenance activities are required as a result of flood flows. The fall inspection will be to assure that the structural measures are in satisfactory condition to function through the coming flood season. The inspection group will consist of representatives of the three sponsoring agencies and the Soil Conservation Service and may include representatives of other interested agencies.

Specific maintenance agreements will be executed prior to the issuance of invitation to bid for any construction contract. The Santa Clara County Flood Control and Water Conservation District is fully aware of all its responsibilities in this regard.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST
Llagas Creek Watershed, California

Installation Cost Item	Unit	Number 2/	Estimated Cost (Dollars) 1/ PL. 566 Funds	Other	Total
LAND TREATMENT					
Soil Conservation Service					
Proper Range Use	Acre	5,230		9,200	9,200
Range Seeding	Acre	250		2,800	2,800
Proper Pasture Use	Acre	1,140		1,700	1,700
Pasture Planting	Acre	200		3,500	3,500
Spring Development	No.	13		5,200	5,200
Farm Ponds	No.	6		9,000	9,000
Fertilization	Acre	2,950		59,000	59,000
Cover Cropping	Acre	2,185		43,700	43,700
Crop Residue Use	Acre	1,900		2,900	2,900
Conservation Cropping System	Acre	725		700	700
Grade Stabilization Structures	No.	60		26,700	26,700
Grass Waterways	Acre	20		1,900	1,900
Stream Channel Improvement	Mile	12		72,000	72,000
Stream Bank Protection	Mile	1		5,000	5,000
Surface Field Ditches	Mile	10		2,000	2,000
Diversions	Mile	2		2,000	2,000
Land Smoothing	Acre	1,000		30,000	30,000
Erosion Control Structures	No.	40		8,000	8,000
Improved Water Application	Acre	3,225		16,100	16,100
Land Leveling	Acre	325		24,400	24,400
Technical Assistance	Dollar		44,100	16,600	60,700
SCS Sub-total			44,100	342,400	386,500
Forest Service					
Roads - Conventional	Mile	1.8	17,550	17,550	35,100
Roads - Ridge Top (4 wheel drive)	Mile	23.8	23,800	23,800	47,600
Roads - Other (4 wheel drive)	Mile	0.3	2,250	2,250	4,500
Roads - Stabilization Fills	Dollar		500	500	1,000
Firebreaks - 75' to 150'	Mile	19.9	13,930	13,930	27,860
Firebreaks - 75'	Mile	6.0	3,000	3,000	6,000
Water Tanks	No.	3	750	750	1,500
Helispots	No.	12	2,700	2,700	5,400
Technical Assistance	Dollar		16,360	16,360	32,720
Land, Easements & R/W				63,620	63,620
FS Sub-total			80,840	144,460	225,300
TOTAL LAND TREATMENT			124,940	486,860	611,800
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	No.	1	406,000		406,000
Revising Outlet Works	No.	1	8,100	14,900	23,000
Stream Channel Improvement	Miles	20.6	3,399,000		3,399,000
Sub-total - Construction			3,813,100	14,900	3,828,000
INSTALLATION SERVICES					
Soil Conservation Service					
Engineering Services			676,000		676,000
Other			210,000		210,000
Sub-total - Installation Services			886,000		886,000
OTHER COSTS					
Land, Easements, and rights-of-way				1,209,500	1,209,500
Administration of Contracts and State Dam Filing Fee				45,000	45,000
Utility Relocations				1,369,000	1,369,000
Sub-total - Other Costs				2,623,500	2,623,500
TOTAL STRUCTURAL MEASURES			4,699,100	2,638,400	7,337,500
TOTAL PROJECT			4,824,040	3,125,260	7,949,300
Summary					
Sub-total - Soil Conservation Service			4,743,200	2,980,800	7,724,000
Sub-total - Forest Service			80,840	144,460	225,300
TOTAL PROJECT			4,824,040	3,125,260	7,949,300

1/ Price Base 1962
2/ No Federal land in watershed.

1962

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT
(at time of work plan preparation)

Llagas Creek Watershed, California

Measures	Unit	Applied to Date	Total Cost (Dollars) 1/
(1)	(2)	(3)	(4)
LAND TREATMENT			
Proper Range Use	Acre	6,010	10,500
Range Seeding	Acre	50	600
Proper Pasture Use	Acre	3,740	5,600
Pasture Planting	Acre	200	3,500
Spring Development	No.	30	12,000
Farm Ponds	No.	12	18,000
Fertilization	Acre	6,990	139,800
Cover Cropping	Acre	5,000	100,000
Crop Residue Use	Acre	6,800	10,200
Conservation Cropping System	Acre	1,400	1,400
Grade Stabilization Structures	No.	4	1,800
Land Smoothing	Acre	500	15,000
Erosion Control Structures	No.	5	1,000
Improved Water Application	Acre	4,295	21,500
Land Leveling	Acre	3,683	276,200
Fire Station	No.	1	35,000
Bulldozer with Transport	No.	1	20,000
Helispots	No.	1	450
Water Development	No.	1	500
Sub Total			673,050
STRUCTURAL MEASURES			
Agricultural Water Management			
Dam and Reservoir	No.	1	1,000,000
Channel Improvement			600
Flood Prevention			
Channel Improvement - Clearing, Snagging, Widening, and Deepening of Llagas Creek			10,000
Sub Total			1,010,600
TOTAL	xxx	xxx	1,683,650

1/ Price Base 1962

TABLE 2 - ESTIMATED COST DISTRIBUTION
LLAGAS CREEK WATERSHED, CALIFORNIA

Structure Identification	Installation Cost-P.L. 566 Funds				Installation Cost-Other Funds					
		Installation Services				Other				
	Construction	Engineering	Other	Total P.L. 566	Construction	Adm. of Contracts	Easements & R/W	Bridges & Reloc.	Total Other	Total Installation Cost
Llagas Creek Channel Improvement										
Sta. 92+00 to 191+00	667,000	113,000	37,000	817,000		7,000	132,000	128,000	267,000	1,084,000
Sta.191+00 to 357+50	939,000	160,000	52,000	1,151,000		9,000	154,000	213,000	376,000	1,527,000
Sta.357+50 to 458+00	385,000	65,000	21,000	471,000		4,000	81,000	5,000	90,000	561,000
Sta.458+00 to 498+15	134,000	23,000	7,000	164,000		1,000	30,000	51,000	82,000	246,000
Sta.498+15 to 580+00	205,000	35,000	11,000	251,000		2,000	73,000	3,000	78,000	329,000
Sta.580+00 to 650+00	9,000	1,000	1,000	11,000		-	59,000	-	59,000	70,000
Sta.650+00 to 703+70	135,000	23,000	7,000	165,000		2,000	45,000	3,000	50,000	215,000
Sta.703+70 to 735+00	86,000	15,000	5,000	106,000		1,000	21,000	1,000	23,000	129,000
Subtotals	2,560,000	435,000	141,000	3,136,000		26,000	595,000	404,000	1,025,000	4,161,000
Miller Slough Channel Improvement										
Main Channel										
Sta. 0+00 to 60+00	72,000	12,000	4,000	88,000		1,000	34,000	13,000	48,000	136,000
Sta. 60+00 to 124+00	207,000	35,000	11,000	253,000		2,000	127,000	61,000	185,000	438,000
Sta. 124+00 to 160+00	31,000	5,000	2,000	38,000		1,000	62,000		63,000	101,000
South and North Channels										
Sta. 160 to 212 & 175 to 220	70,000	12,000	4,000	86,000		1,000	97,000	101,000	199,000	285,000
Subtotals	380,000	64,000	21,000	465,000		5,000	315,000	175,000	495,000	960,000
West Branch Llagas Creek Channel Improvement										
Diversion Channel										
Sta. 0+00 to 110+00	281,000	48,000	15,000	344,000		3,000	116,000	274,000	393,000	737,000
Main Channel										
Sta. 110+00 to 181+50	104,000	18,000	6,000	128,000		1,000	43,000	38,000	82,000	210,000
West Channel										
Sta. 110+00 to 170+00	74,000	13,000	4,000	91,000		1,000	37,000	28,000	66,000	157,000
Subtotals	459,000	79,000	25,000	563,000		5,000	196,000	340,000	541,000	1,104,000
Raising Cresbro Dam										
Dam and Reservoir-Except Outlet Works	406,000	74,000	22,000	502,000		8,500	103,500	450,000	562,000	1,064,000
Relocation Outlet Works Intake Structure	8,100	4,000	1,000	13,100	14,900	500	-	-	15,400	28,500
Subtotals	414,100	78,000	23,000	515,100	14,900	1/ 9,000	103,500	450,000	577,400	1,092,500
Geologic Exploration for Riprap		20,000		20,000						20,000
GRAND TOTALS	3,813,100	676,000	210,000	4,699,100	14,900	45,000	1,209,500	1,369,000	2,638,400	7,337,500

TABLE 3 - STRUCTURE DATA

RAISING EXISTING CHESBRO DAM

Llagas Creek Watershed, California

Item	Quantity
Drainage Area	18.9 Sq. Miles
Storage Capacity	
Existing Sediment	110 Ac. Ft.
Existing Conservation	7,520 Ac. Ft.
Floodwater Detention	3,570 Ac. Ft.
Total	11,200 Ac. Ft.
Surface Area	
Existing Sediment Pool	15 Acres
Existing Conservation Pool	275 Acres
Floodwater Detention Pool	327 Acres
Elevation Top of Dam	546 Feet
Maximum Height of Dam	
Existing Structure	105 Feet
Raised Height	11 Feet
Total	116 Feet
Emergency Spillway	
Crest Elevation	537
Crest Width	80 Feet
Type	Concrete Chute
Frequency of Use	1 Percent
Emergency Spillway Hydrograph	(not used) 1/
Freeboard Hydrograph	
Storm Rainfall (6-Hr.)	17.5 inches
Runoff Curve Number (Cond. II)	68
Storm Runoff	13.0 inches
Max. Inflow	20,350 cfs.
Max. Outflow	11,000 cfs.
Max. W.S. Elevation	545 Feet
Principal Spillway	
Type	Concrete Chute 2/
Capacity	2,910 cfs.
Design Hydrograph	
Max. Inflow	6,400 cfs.
Max. Outflow	2,910 cfs.
Capacity Equivalents	
Existing Sediment Volume	0.11 inches
Existing Conservation Volume	7.44 inches
Detention Volume	3.56 inches
Spillway Storage	3.10 inches
Class of Structure	C

1/ The emergency spillway hydrograph is considerably smaller than the 1 percent design hydrograph.

2/ The principal spillway is a 25 foot x 12 foot concrete rectangular weir designed as a notch in the weir which forms the crest of the emergency spillway and they both discharge into the existing concrete chute.

TABLE 3A - STRUCTURE DATA

GRADE STABILIZATION STRUCTURES

Llagas Creek Watershed, California

Location	Drop (Ft.)	Spillway Width (Ft.)	Depth of Water Over Crest (Ft.)	Concrete (C.Y.)
LLAGAS CREEK				
Station 107+50	0.0	107	15	359
Station 129+50	6.0	107	15	292
Station 150+00	4.0	130	15	278
Station 165+00	4.0	130	15	312
Station 191+50	9.0	118	12½	306
Station 255+50	3.5	118	12½	274
Station 298+90	2.0	112	13	267
Station 334+00	3.0	107	13	260
Station 358+00	4.0	100	10½	235
Station 386+00	2.5	100	10½	227
MILLER SLOUGH				
Main Channel				
Station 60+00	13.2	8.0	6.0	246
Station 160+00	2.0	4.0	4.0	45
South Channel				
Station 175+00	2.0	9.0	4.8	60
WEST BRANCH LLAGAS CREEK				
Main Channel				
Station 110+00	6.0	40.0	7.2	220
Station 135+00	3.0	40.0	7.2	181
West Channel				
Station 132+00	9.0	8.0	4.0	133
Station 162+00	4.0	35.0	4.0	107
LIVE OAK CREEK	4.0	7.0	8.5	152
PANTHER CREEK	4.0	8.0	10.0	186

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TABLE 3B - STRUCTURE DATA

CHANNELS

Reach	Drawing No.	Watershed Area (Sq. Mi.)	Planned Channel Capacity(cfs.)	Waterway Area (Sq. Ft.)	Channel Gradient (Ft./Ft.)	Velocity (Ft./Sec.)	Bottom Width (Ft.)	Water Depth (Ft.)
LLAGAS CREEK								
92+00 to 95+00	L-1	78.5	16,140	2,020	0.0014	7.9	182	10
95+00 to 107+50	L-1	78.5	16,140	2,020	0.0014	7.9	182	10
107+50 to 150+00	L-1	78.5	16,140	2,055	0.0009	7.8	107	15
150+00 to 191+00	L-1	78.5	16,140	2,400	0.0009	6.7	130	15
191+00 to 298+93	L-1	71.1	13,410	1,790	0.0014	7.5	118	12½
298+93 to 314+00	L-1	71.1	13,410	1,790	0.0010	7.5	112	13
314+00 to 329+35	L-1	69.9	13,130	1,770	0.0010	7.4	110	13
329+35 to 357+50	L-1	68.3	12,720	1,730	0.0010	7.3	107	13
357+50 to 386+30	L-1	58.9	9,290	1,270	0.0012	7.3	100	10½
386+30 to 450+00	L-2	54.5	8,900	1,150	0.0020	7.7	95	10
450+00 to 458+00	L-2	54.5	8,900	1,060	0.0024	8.4	86	10
458+00 to 498+15*	L-2	34.4	4,920	608	0.0031	8.0	60	8
498+15 to 513+00	L-2	34.4	4,920	608	0.0030	8.0	60	8
513+00 to 580+00	L-2	34.4	4,920	694	0.0026	7.0	85	7
580+00 to 650+00	L-2	34.4	4,920	No Channel Improvements required				
650+00 to 687+00	L-2	34.4	4,920	645	0.0030	7.5	78	7
687+00 to 703+70	L-2	34.4	4,920	553	0.0042	8.8	65	7
703+70 to 735+00	L-2	27.3	3,430	392	0.0045	8.7	42	7

* Equation - 483+50 = 487+35

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TABLE 3B STRUCTURE DATA

CHANNELS (continued)

Channel Name	Reach	Drawing No.	Watershed Area (Sq. Mi.)	Planned Channel Cap.(cfs.)	Waterway Area (Sq. Ft.)	Channel Gradient (Ft./Ft.)	Veloc. (Ft./Sec.	Bottom Width (Ft.)	Water Depth (Ft)
MILLER SLOUGH									
Main Channel	0+00 to 20+00	M-1	7.4	3,220	720	0.0005	4.6	18.0	15.0
	20+00 to 60+00	M-1	5.5	2,400	570	0.0005	4.3	8.0	15.0
	60+00 to 92+00	M-1	4.5	1,900	432	0.0010	4.6	60.0	6.0
	92+00 to 130+00	M-1	3.5	1,580	300	0.0015	4.6	38.0	6.0
	130+00 to 160+00	M-1	3.0	1,360	264	0.0015	5.2	32.0	6.0
	160+00 to 180+00	M-1	0.4	160	48	0.0015	3.3	4.0	4.0
South Channel	160+00 to 175+00	M-1	2.6	1,120	192	0.0020	5.7	20.0	6.0
	175+00 to 212+00	M-1	1.0	490	89	0.0030	5.5	9.0	4.8
North Channel	175+00 to 220+00	M-1	1.3	630	126	0.0020	5.1	9.0	6.0
WEST BRANCH LLAGAS CREEK									
Main Channel	0+00 to 110+00	WBL-1	10.4	3,900	923	0.0004	4.3	45.0	13.0
	110+00 to 181+50	WBL-1	6.1	2,540	392	0.0020	6.8	40.0	7.2
West Channel	110+00 to 132+00	WBL-1	2.0	1,380	442	0.0003	3.1	8.0	13.0
	132+00 to 170+00	WBL-1	1.3	1,060	172	0.0035	6.4	35.0	4.0

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TABLE 4 - ANNUAL COST

Llagas Creek Watershed, California

(Dollars) 1/

Evaluation Unit	Amortization of 2/ Installation Cost	Operation and Maintenance Cost	Total
West Branch Llagas Creek	44,400 3/	10,400	54,800
Llagas Creek Miller Slough	220,800 3/	27,600	248,400
TOTAL	265,200	38,000	303,200

1/ Price Base 1962

2/ 50 year life, 2 5/8% interest rate.

3/ See Page 53 "Allocating Costs Between Evaluation Units".

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TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Llagas Creek Watershed, California

(Dollars) 1/

Item	Estimated Average Annual Damage		Damage Reduction Benefit
	Without Project	With Project 2/	
Floodwater			
Crop and Pasture	33,900	0	33,900
Urban	477,200	0	477,200
Subtotal	511,100	0	511,100
Sediment			
Overbank deposition	90,200	0	90,200
Subtotal	90,200	0	90,200
Indirect	88,200	0	88,200
Total	689,500	0	689,500

1/ Price base 1962

2/ The effects of ponding from local precipitation have been abstracted, i.e. only streambank overflow has been considered. With 1 percent control no residual flooding remains.

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TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Llagas Creek Watershed, California

(Dollars) 1/

Evaluation Unit	AVERAGE ANNUAL BENEFITS		Average Annual Cost	Benefit Cost Ratio
	Flood Prevention			
	Damage Reduction	Total		
West Branch Llagas Creek	150,200	150,200	54,800	2.7
Llagas Creek	485,200	485,200	248,400	2.0
GRAND TOTAL	635,400 2/	635,400	303,200	2.1

1/ Price base 1962

2/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of 54,100 annually.

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TABLE 7 - CONSTRUCTION UNITS

Llagas Creek Watershed, California

(Dollars) 1/

Measures in Construction Unit	Annual Benefit	Annual Cost
West Branch Llagas Creek	150,200	54,800
Llagas Creek	485,200	248,400

1/ Price base 1962

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INVESTIGATIONS AND ANALYSES

PROJECT FORMULATION

This watershed work plan incorporates the practical experience of many people who live within the watershed. The intimate knowledge of the flood problem of the Loma Prieta Soil Conservation District, the water management experiences of the South Santa Clara Valley Water Conservation District, and the technical help of the Santa Clara County Flood Control and Water Conservation District have all greatly facilitated formulation of the work plan. The technical knowledge of the California Division of Soil Conservation, the U. S. Soil Conservation Service, the U. S. Army Corps of Engineers, the California Division of Forestry, the California Department of Water Resources, and other Federal, State, and local organizations have been utilized.

The objectives of the local people are to establish a program of land treatment practices and structural measures that will maintain and protect the watershed, reduce the incidence and hazard of fire, and prevent flooding. A corollary requirement is that the objectives be accomplished without impairment of the existing facilities for recharging underground aquifers.

The many points of view of the local people were given full consideration in deriving this plan, and as many of their suggestions as could be included within the framework and limitations of Public Law 566 are found herein. The sponsors and other interested local agencies were kept fully informed of the findings in each stage of project development by the Division of Soil Conservation and were consulted each time a choice among alternate schemes was to be made.

LAND TREATMENT MEASURES

The land treatment measures, with the exception of the intensified fire protection program, were developed by technicians of the Soil Conservation Service and are based on the technical standards that they have developed from years of experience. The basic data consisted of a detailed tabulation of land within the watershed giving land classes, uses, and capabilities. From this, an inventory was made of the conservation needs of the watershed area and the corresponding land treatment measures required to fill these needs. Also inventoried at this time (see Table 1A) were the land treatment measures that have been previously installed. The list of needed measures was then reduced so as to include only those that would have a measurable effect upon the production of floodwater and sediment or would be necessary to achieve the full benefit of the planned structural measures. The total conservation need quantities were next reduced by the amount of measures presently installed and then further reduced to reflect the amounts of practices that could reasonably be accomplished during the project installation period with the optimum technical staff. These amounts were also checked to make sure that land treatment will be provided to 50 percent of the land above Chesbro Reservoir. The final selected measures, quantities, and costs are found on Table 1. The accelerated program requires more technical assistance than the present staff can provide during the

installation period, and costs for the additional amount will be met from Public Law 566 funds.

The intensified fire protection program developed by the California Division of Forestry in cooperation with the sponsoring local organizations represents many years of experience of the Division in suppressing fires in this area. The development of the plan called for a careful review of available information on past fire incidence, causes, damages, extent and location of burns, rate of spread, and intensity. The potential fire hazard and risk was determined by evaluating such factors in the existing fire control program as detection, communications, travel times, attack forces, and equipment as to their adequacy based on projected land use.

The objective of project formulation was to reduce the average annual burn rate from the present annual average of 1.88 percent to an optimum level considering both the associated benefits and costs. The present burn rate was determined from a study of fire history in the general area of the project in order to avoid prejudicing the results by temporary local variation within the watershed. Plans were developed for reducing the burn rate from the present value to the reduced values of 1.75 percent, 1.50 percent, 1.25 percent, 1.00 percent, 0.75 percent, 0.50 percent, and 0.25 percent. To achieve each decrease in burn rate, the plan required additional roads, firebreaks, and other facilities. The plan finally selected reduces the average annual burn rate to 0.75 percent, represents the "best buy" concept, and is preferred by the sponsors.

The tentative program includes roads designed to reduce travel time to newly discovered fires, firebreaks to divide the area into small blocks and thus reduce the average size of burned area per fire and prevent fires originating outside the watershed from entering, water tanks, and helispots designed to speed transportation of men and equipment for fire fighting. The selected measures, quantities, and costs for intensification beyond the level of the going program are found on Table 1.

STRUCTURAL MEASURES

Principles

The basic objective of the structural works of improvement included in this work plan is to provide, within estimating accuracy, the maximum net flood protection to the watershed without regard to the relative Federal and non-Federal costs and to fulfill, insofar as sound economic and engineering practice will allow, the desires of the sponsoring groups.

During project formulation consideration was given to numerous alternate kinds and locations of measures, types of materials, and levels of protection. Care was also exercised to insure that nothing is proposed for the present which would preclude a more comprehensive future development either within the watershed itself or within the adjacent Little Llagas Watershed. Special caution was exercised to make sure the project has no adverse effects on future downstream development by the U. S. Army Corps of Engineers.

Scope of the Project

Although the flood problems in several adjacent watersheds were analyzed for possible inclusion in this work plan, it was determined that the criteria of Public Law 566 would best be met by handling the Llagas Creek Watershed alone. The measures presented in this work plan are sufficient to solve the problem in this area independent of any possible work either downstream from the project or in the tributary Little Llagas Watershed. In fact, the design capacity of the improved Llagas channel allows for a probable diversion of Little Llagas waters into Llagas Creek just upstream from U. S. Highway 101 and the increased flows that will be realized when Little Llagas Creek becomes channelized.

Alternate Kinds of Measures

Preliminary to the preparation of this work plan, numerous combinations of channel alignment and detention storage were evaluated. The total combined cost of providing flood detention and downstream channel improvement was computed for amounts of flood detention on Llagas Creek varying between none and 5,580 acre-feet. Comparing this total cost with flood storage showed 3,500 acre-feet to be the optimum flood detention requirement. Detailed inspection of the watershed revealed no feasible reservoir sites on the tributary creeks, and an investigation of the tributary Little Llagas Watershed showed that there too no possibility of any flood detention exists.

Alternate Structure Locations

To determine the best method of providing flood detention storage on Llagas Creek, comparative costs were made for an offstream storage site, increasing the capacity of the existing Chesbro Reservoir, and building a new onstream reservoir. In the last case, three possible sites were considered. When increasing the capacity of Chesbro Reservoir was found to be the most economical choice, further studies were made to find the best method of raising the existing dam and modifying the existing spillway. These studies resulted in the plan to raise the earth dam by placing additional embankment on the upstream face and modifying the entrance to the existing spillway while utilizing its concrete-lined chute.

Numerous different channel locations were also analyzed before the final plan was derived. In general, the first plan considered followed the existing channel and every departure therefrom was justified through a cost comparison. Several alternate diversion schemes between West Branch Llagas and Llagas Creeks were also studied. As a result of these studies, the proposed improvements on Llagas Creek follow the existing channel except for the elimination of numerous sharp curves. However, for the area upstream from Gilroy on West Branch Llagas Creek, the more desirable alternate was found to be to divert runoff directly into Llagas Creek rather than bring it through town as is done at present. It was also found to be more desirable to divert Miller Slough into Llagas Creek upstream from the Pacheco Pass Highway rather than to bring it in at its present location. A comparative study was also made to determine the best means of providing flood control in the Little Llagas

Watershed. Since this study showed that a separate diversion into Llagas Creek of the flows originating in the Little Llagas Watershed upstream from U. S. Highway 101 is the most economical means of providing flood control and since this diversion will probably be made in the next several years, provision was made for this additional flow in Llagas Creek. On Llagas Creek backwater computations were made for the entire distance between its mouth and Chesbro Reservoir, and channel improvement is provided wherever the existing capacity was found insufficient to handle the design storm. Channel improvement work is provided on the tributary channels wherever historical flooding has been extensive. The final plan thus finds the main Llagas channel being improved on substantially its present alignment with the tributary channel system being realigned to achieve greater project economy.

Alternate Types of Material

Construction materials to be used in raising Chesbro Dam are largely dictated by existing construction. The dam embankment will remain homogeneous earth fill, but concrete gravity walls will be added in the spillway area.

On Llagas Creek a balance was achieved between the number and size of drop structures and channel excavation and lining cost. For those reaches requiring lining, ungrouted riprap was used in preference to other materials in order to keep interference with percolation to a minimum as well as for cost reasons. Lining was also found to be less costly than enlarging the channel and installing additional drop structures to reduce velocities.

For all tributary channels, any type of lining was found to be uneconomical. Special studies for the reach of Miller Slough through Gilroy proved lining uneconomical in this area if runoff from the upper watershed is diverted to Llagas Creek; however, in proving the feasibility of this diversion, some trapezoidal concrete lining was used in the estimate for the alternate of taking all the runoff through town. Wherever reasonable doubt existed, a comparative cost study was made between lined and unlined channel for each reach.

Alternate Levels of Protection

The benefits and costs for various levels of protection were evaluated in order to determine the optimum project. The additional benefits and costs associated with each increase in the level of protection were determined and then both plotted against frequency. The optimum level of protection (defined as the maximum level at which incremental costs equal incremental benefits) was thus found for this watershed to be 1.5 percent. However, in order to satisfy the criteria on minimun level of protection for urban areas of the California Soil Conservation Commission, all structural measures were designed to protect against a 1 percent flood.

HYDROLOGIC INVESTIGATION

WATERSHED HYDROLOGY

About 90 percent of the precipitation and all of the historical flooding within the Llagas Watershed have occurred between November 15 and April 15. Average annual precipitation varies roughly with elevation within the watershed and ranges from about 19 inches at the lowest elevations to over 40 inches at the highest. Snowfall is negligible even at the highest elevations. Flooding within the watershed is almost exclusively associated with cyclonic storms that move in from the Pacific and generally exceed 12 hours' duration.

The vegetative cover pattern, like precipitation, varies with elevation. The general pattern is row crop farming on the lowest valley lands, orchard within the main valley area, small grain and pasture on the higher valley lands, range land in the foothills, and dense brush and some timber in the higher hills. Percentage of runoff for equal rainfall amounts is substantially higher from the valley areas than from the hills.

Precipitation data from seven gages, including four recording gages, within or adjacent to the watershed were analyzed. Data sources included the U. S. Weather Bureau, the California Department of Water Resources, and the U. S. Army Corps of Engineers. The data were analyzed by the method of the California Department of Water Resources and compared with Weather Bureau findings and the Corps of Engineers' bulletin, "Ten-Year Storm Precipitation in California and Oregon Coastal Basins."

Stream flow records for a 5-year period on Llagas Creek and a 27-year period on nearby Uvas Creek were obtained from U. S. Geological Survey records. One-year records at four other points in or near the watershed were obtained from the Department of Water Resources. Because of its longer record, the Uvas Creek gage was used as the key gage from which peak and volume flows for various frequencies were determined.

HYDROLOGY FOR ECONOMIC STUDIES

Analysis of major historical flooding is the basis for the determination of area inundated versus frequency curves. Minor flooding was not thoroughly investigated since none has occurred since 1958 and reliable data are difficult to obtain for events prior to that date. Thus, the three basic points used in developing area inundated versus frequency curves were the areas inundated and the associated frequencies for the floods of 1955 and 1958 and the point at which flooding begins or existing channel capacity as found in a backwater analysis. Flood data for December, 1955, and April, 1958, were obtained from field interviews by California Division of Soil Conservation personnel and partially substantiated by photographs taken during the flooding. Supplemental records were obtained from the Red Cross, the California Department of Water Resources, the U. S. Army Corps of Engineers, and the Santa Clara County Flood Control District.

The process for determining area inundated versus frequency curves involved developing a peak discharge versus frequency curve from stream gage and rainfall records; determining the frequency of the 1955 and 1958 floods and the beginning of flooding from the same basic data; combining the above data into a peak flow versus area inundated curve and plotting area-inundated versus frequency from the previously plotted curves relating both these variables to peak flow.

Data for areas inundated by depth increments were obtained for the 1955 flood by field interview. Total area inundated by floods of different frequency was found through the use of the previously established area-inundated versus frequency curve.

HYDROLOGY FOR STRUCTURAL DESIGN

Design hydrographs were computed using methods outlined in Section 3.21 of the Hydrology Guide.

Various factors used in hydrograph computation, such as time of concentration, curve numbers, and storm distribution curves, were developed by using Soil Conservation Service methods of analysis so that indicated peak discharges, volumes, and hydrographs shapes closely approximated derived frequency curves and known events. Design hydrographs, based on the 24-hour storm, were routed through the proposed enlarged Chesbro Reservoir by the storage indication method and through the proposed improved channels by the Wilson method for combining to form composite hydrographs for the various design reaches on Llagas Creek.

HYDROLOGIC EVALUATION OF LAND TREATMENT MEASURES

On-the-farm land treatment measures were evaluated by computing the effect of these measures on composite curve numbers according to material in Section 3.7 of the Hydrology Guide.

Runoff volumes were reduced to show the effect of the curve number change due to land treatment. Peak flows were then proportionately reduced. For economic evaluation these peak flow reductions were translated into area-inundated reductions by the same procedure used in computing the original area-inundated versus frequency curves.

Fire protection measures were evaluated both with respect to flood peak and to sediment reduction. Flood peak reduction was evaluated by determining the change in runoff curve number by a method developed by the Division of Soil Conservation based on studies conducted by the Pacific Southwest Forest and Range Experiment Station. Change in curve number was translated to area-inundated reduction by the process previously outlined for other land treatment measures. Sediment reduction was evaluated through a similar method based on the same research program. The percentage reduction found from this formula was applied directly to sediment deposition within Chesbro Reservoir and weighted according to the portion of the watershed downstream from the dam requiring fire control measures to determine reduction in the lower watershed.

GEOLOGIC INVESTIGATION

AREAL GEOLOGY

The Llagas Creek Watershed is probably entirely underlain at depth by rocks of the Franciscan formation of Jurassic and Cretaceous age. These rocks consists of a wide variety of lithologic type including sandstone, shale, and chert. Other sedimentary rocks present in small amounts are conglomerate and limestone. The sediments have been intruded by igneous bodies such as serpentine, peridotite, and diabase. Interbedded volcanics also occur. The Franciscan is exposed in the upper watershed on the west side of the valley. Also cropping out in this part of the watershed are several Tertiary and Cretaceous sedimentary units of relatively minor extent.

The narrow portion of the watershed located to the east of the valley floor is separated from the main range further east by the trace of Calaveras and other faults. This area is predominantly underlain by continental deposits of sandstone, shale and conglomerate of Cenozoic age. Small bodies of volcanic rocks of relatively recent age are found interbedded with the continental deposits which form the greater part of the range. Isolated bodies of various types of Franciscan rocks occur between the major faults.

The valley floor is a down-dropped block between relatively uplifted mountains on either margin. Quaternary alluvium has been deposited in the valley to depths up to 400 feet, and the total thickness of relatively unconsolidated sediments is very probably in excess of 1,000 feet when the underlying Plio-Pleistocene deposits are included. Temporary damming of surface outflow from the valley caused the periodic deposition of tight, clayey lake beds which are now aquicludes that confine several subsurface water bodies in the lower South Santa Clara Valley.

SEDIMENTATION

Sediment damages ascribable to reservoir and overbank deposition and stream aggradation are now insignificant in Llagas Creek Watershed. Chesbro Reservoir on Llagas Creek was empty at the time of the investigation and afforded an excellent opportunity to evaluate sediment production in the upper watershed. Negligible amounts of recent fine sand deposition were found in the former river courses. Although occasionally reaching one foot in depth, the limited areal extent of the deposits indicated an extremely low rate of sediment production. The estimated average rate of sediment production was taken as 0.2 acre-feet per square miles of watershed per year; but under present conditions, near optimum watershed cover with no recent burns, the rate of deposition appears to be considerably less than the estimated average annual rate. With the installation of the proposed fire control program, these optimum cover conditions will be maintained and the average annual rate of sediment production will be about 0.12 acre-feet per square mile.

The extent of overbank deposition, although reportedly of considerable magnitude during the floods of 1955 and 1958, was impossible to evaluate in the field at this time. During the drilling of the test

holes for use in channel design, no such recent surficial deposits were noted beyond an occasional deposit of silty sand less than one foot in thickness. Most holes began in dark grey to black, well-developed, plastic clay soils.

A short distance upstream from the U. S. 101 Highway bridge on Llagas Creek a flattening of stream gradient has caused the coarsest portion of the bed load in transport to be deposited. This accumulation of well-rounded, hard pebbles and cobbles is being removed for use as road material.

Although the downstream reaches of Llagas Creek extending approximately to the Pacheco Pass Highway contain a gravelly bed load, this material, which probably never reaches the Pajaro River, is thought to be derived largely from limited erosion of the adjacent banks. Erosion of these banks is not excessive and the stream is probably in near equilibrium with its bed load. Downstream attrition of the gravels apparently reduces them to sizes capable of being carried as suspended load.

Sediment damages have been evaluated for the economic analysis as a percentage of total flood damages. Of total agricultural and urban damage, 85 percent was estimated to be associated with floodwater and 15 percent with sediment.

EROSION

Erosion in the upper Llagas Creek Watershed is not noticeable under the present excellent cover conditions. While some small areas contain occasional shallow rills, neither sheet nor rill erosion is presently a problem. Inasmuch as these soils are inherently erodible, an abrupt increase in sediment yield would occur immediately following an extensive fire.

Erosion in the valley reaches of Llagas Creek is confined to local bank erosion. This may be due to the stream's efforts to maintain a fully satisfied bed load condition. Without bank protection this condition may become more serious in the distant future since the bed load in transit from the upper watershed has now been cut off by Chesbro Reservoir. Again a widespread fire could accelerate bank erosion by aggradation of Llagas Creek channel.

Land loss has been reported on the north bank of Llagas Creek upstream from U. S. Highway 101. This area, estimated at slightly larger than two acres, probably suffered a loss of top soil only.

No erosion damages from any of the above causes were monetarily evaluated in the economic evaluation of the project.

CHESBRO DAM

The work plan proposes to raise Chesbro Dam by 11 feet to detain flood volumes. The increase in height will be accomplished by removing the existing riprap on the upstream face and placing sufficient fill

against the dam to bring the crest to the required elevation. The new upstream face will then be riprapped with rock larger than that used on the original dam. The outlet works will be extended upstream to prevent the present entrance from being covered by the additional fill. The present emergency spillway crest will be modified and raised, but the chute portion will remain unchanged.

The right abutment and a portion of the channel section of the dam are founded on sheared sediments, chiefly graywacke, of the Franciscan formation. The left abutment and the remainder of the channel section are composed of a fairly massive variety of serpentine containing locally, unaltered pods of the parent peridotite. Although not ideal foundation material, the stability of the dam at its present height indicates these rocks are certain to support the relatively small surcharge of the additional fill. An evaluation of the logs of the exploratory holes drilled for the original dam corroborates this contention. While some additional settlement of the existing fill material can be anticipated, it is not expected to be of sufficient magnitude to seriously affect either the dam or outlet works.

In the vicinity of the new spillway crest structure, a shallow cutoff will be required in the sheared graywacke. This excavation can probably be ripped and dozed although explosives may have to be used for individual enclosures of hard graywacke or dike rock. Considerable care will have to be exercised in this operation to prevent further shattering of the abutment rock. The graywacke is competent to support the proposed gravity retaining wall with its foundation pressure up to about three tons per square foot.

Material for the additional embankment can be obtained from the floor of the reservoir. The characteristics of the old and new fill will thus be almost identical.

CHANNEL INVESTIGATION

Early in the Llagas Creek investigation a few bank material samples were obtained and primary testing performed for use in preliminary estimates of the cost of channel improvements. After the project had demonstrated an element of feasibility, a program of test hole drilling was conducted during which additional samples were secured and tested. Holes were drilled adjacent to the existing channel to depths of at least five feet below the proposed channel bottom except in those cases where the exploratory holes were stopped short of the required depth by lenses of coarse gravel. A total of 350 feet of hole was drilled at 23 locations along Llagas Creek and Miller Slough, and 52 representative samples were tested for mechanical analysis and Atterburg limits. The location and logs of exploratory holes are shown on the channel profile sheets. In plastic soils the results of this testing were used in the design of the proposed channels by tractive force and limiting velocity criteria. Additional materials' investigations will be made in the final design stage to more precisely evaluate required bottom and bank stabilization measures.

For those reaches in nonplastic soils, channel design was based on grain size. However, the samples secured in these reaches were not thought to be representative because of the inability of the auger drill rig to bring the larger gravels to the surface. In these cases the size of the gravel that is larger than 75 percent of the armor coat was estimated in the field. The design velocity was then calculated on the assumption that this size gravel would concentrate in and protect the proposed channel bottom.

MATERIALS

Three potential sources of riprap were investigated: (1) A basalt deposit approximately four miles northeasterly of Gilroy; (2) a high cliff of silica-carbonate rock immediately north of the basalt; and (3) a large existing quarry in Chittenden Pass which produces from a diorite-gabbro body.

It is expected that any of these sources would supply suitable riprap for use as channel lining and as slope protection on the upstream face of Chesbro Dam.

Since there is some question concerning the location, quantity, and blasting quality of the first two of the above sources, an item of $20,000 is included in the project installation cost to provide for detailed exploration of these two potential quarries. If both of these sources prove unsatisfactory, rock may be hauled from the quarry at Chittenden Pass.

The relatively small amount of concrete aggregate required can easily be obtained from any of the several nearby commercial sand and gravel operations. Filter materials can be obtained from the same source.

ECONOMIC INVESTIGATION

GENERAL

In order to evaluate flood damages and hence project benefits within the Llagas Creek Watershed, extensive investigations were undertaken to translate the relationships among such elements of flooding as depth, area, duration, season, sediment content, location, and frequency as developed in the hydrologic investigation into dollar damage values. This translation is a twofold process with the first stage requiring the determination of how land use within the flood plain will vary through the life of the project and the second stage requiring evaluating the damages prospective flooding will inflict on the sundry land uses. Once the total damage values were determined, the over-all figure was allocated between the two evaluation units, between agricultural and urban, and between floodwater and sediment.

EVALUATION UNITS

For the economic analysis, the flood plain was divided into two hydrologically independent units. In either of these two units separate

structural measures for flood protection could be economically justified. The first subunit called the West Branch Llagas Creek evaluation unit includes the area west of U. S. Highway 101 that is presently tributary to Miller Slough. The balance of the watershed is included within the Llagas Creek evaluation unit.

LAND USE EVALUATION

Basic data used in ascertaining present land use patterns included field observations, aerial photographs, county publications, and a detailed land use map of the flood plain area prepared by the Department of Geography of Stanford University. Using this map as a base and the other basic data as a guide, figures were developed to show land use within the watershed as it will be in 1965, the approximate date of completion of the project's first elements. These figures are used as representing present conditions for the purpose of land use evaluation.

Four different, independent forecasts were found in the process of evaluating future land use. These were by Griffin and Chatham in a 1958 issue of the "Annuals of the Association of American Geographers," the California Department of Water Resources as part of its preliminary studies for the South Bay Aqueduct; the U. S. Department of Commerce for the use of project planning by the U. S. Army Corps of Engineers; and the Santa Clara County Planning Commission. As the last projection was the most conservative, it was used in estimating the relative amounts of each type of future land use. However, because of the impossibility of determining the exact locations of urban development 20 years hence, no attempt was made to precisely locate each type of future land use once the relative quantity was established.

For the purpose of economic evaluation of flood damages, present land use (1965) and future land use (1985) were thus determined. The pattern is expected to change uniformly from the present to the future state over the first 20 years of project life and then remain constant through the remaining 30 years. This complete discounting of projected urban development occurring more than 20 years in the future adds a further element of conservatism to the estimated damage values.

DETERMINATION OF DAMAGES

Type of Damage

Monetary values developed below include both direct and indirect damages. Direct damages result from direct contact with floodwater and sediment and are evaluated by the process subsequently described. Indirect damages include such items as loss of trade during and after a flood, loss of productive time in replacing or renovating damaged property, loss suffered by users of utilities and communication facilities, and costs incurred in routing traffic, evacuating people, and flood fighting during the period of flooding. Indirect damages were estimated to be 10 percent of direct agricultural damage and 15 percent of direct urban damage.

Agricultural Damages

Agricultural damages were evaluated through the use of a composite crop acre that is forecast to remain constant throughout the project life. Change, if any, will be in the direction of higher value development and will result in a conservative statement of benefits.

The composite crop acre was determined as part of the present land use evaluation. This composite acre consisted of barley and vetch hay, strawberries, and orchard in the West Branch Llagas Creek evaluation unit and these crops plus garlic, baby lima beans, sugar beets, and tomatoes in the Llagas Creek evaluation unit. Representative crop yields and adjusted long-term prices were determined for each of these crops from the Annual Reports of the County of Santa Clara Department of Agriculture. Budgets and curves relating net crop income to yield were determined for each crop by use of the above data plus additional information gleaned from interviewing local farmers, the County Farm Advisor, and others acquainted with local conditions. Direct crop damages were next evaluated from data collected within the watershed on the effects of the 1955 and 1958 floods on the crop budgets and yields, adjusted according to the month of flood occurrence as determined in the hydrologic investigation, and checked against data collected for similar conditions within neighboring watersheds by other agencies. The damage value for the composite acre was then determined by weighting the value for each crop according to the amount of that crop within the composite acre and found to be $37.30 per acre flooded for the West Branch Llagas Creek evaluation unit and $26.45 for the Llagas Creek evaluation unit.

The final step in evaluating agricultural damage was to convert the composite acre values into average annual values for each evaluation unit. Present (1965) and future (1985) damages were found for floods of various magnitude by multiplying the composite acre damage by the number of agricultural acres flooded. By applying an interest rate of 4 percent and assuming a uniform annual acreage change, these two damage values were combined into a single value for each flood magnitude and a curve showing the variation of this value with frequency was plotted. Average annual direct agricultural damages were found from the area under this curve. Indirect damages were evaluated as 10 percent of the direct damages. Total average annual agricultural damages were found to be $2,800 in the West Branch Llagas Creek evaluation unit and $41,100 in the Llagas Creek evaluation unit.

Urban Damages

The basic hydrologic data used in evaluating urban damages were tabulations of area inundated by depth increments for floods of several magnitudes. Present and future land use within each depth increment was determined in the land use studies. The basic tool used in determining damages inflicted by flooding of different depths on urban development was a series of curves developed by Stanford Research Institute in 1960 for California flooding. These curves give damage per $1,000 of market value for residential, commercial, and industrial properties as a function of depth of flooding.

Market values used for commercial, industrial, and residential development within the flood plain are based on such sources as field data, a study made by the Berkeley office of the Soil Conservation Service on future urban development in Southern California, and data for other similar watersheds. Values for each urban use were further adjusted to obtain averages applicable over project life. Final per acre values were $60,000 for residential areas, $170,000 for industrial areas, and $247,000 for commercial areas.

The final step in evaluating direct urban damages of converting the per acre values into average annual values for each evaluation unit was accomplished in the same manner as previously explained for agricultural damages. However, in this case indirect damages amount to 15 percent of the direct damages. Total average annual urban damages were found to be $161,400 in the West Branch Llagas Creek evaluation unit and $484,200 in the Llagas Creek evaluation unit.

Separation of Floodwater from Sediment Damages

All damages were originally computed as combined floodwater and sediment damages. Division of the total values into these two categories was based on an analysis of such factors as soil structure, flow velocities, and cover as well as on the experience of farmers operating a quarter of the land within the flood plain. The final division also agreed with the findings obtained by the U. S. Department of Agriculture in an over-all investigation of the Pajaro River Basin in 1952. The breakdown used was that 85 percent of the total agricultural and urban damages were associated with floodwater and 15 percent with sediment.

Unevaluated Damages

Among those damages that were not monetarily evaluated in this investigation were the direct damages to roads, railroads, and public facilities; erosion damages and damages to farm buildings and equipment; the menace of excessive flooding to public health; the detrimental effect of flooding on areal economy; and the disruption of communication and utility services. The evaluation of direct damages was not completed because additional benefits would have an insignificant influence on both project feasibility and the optimum level of protection.

DETERMINATION OF BENEFITS

Benefits Attributed to Land Treatment Measures

Off-site benefits attributed to land treatment measures were determined from the associated reduction in flooded area found in the hydrologic investigation. The area reductions were translated into monetary values through an approximate method that assumes damages are directly proportional to flooded area. Using this process, benefits of $54,100 annually were attributed to land treatment measures before benefits associated with structural measures were evaluated. Other benefits due to fire control measures consist of such items as reduced fire suppression cost and reduced physical loss of trees, fences, homes, and other property. The land treatment measures applied on individual farms serve to enhance agricultural productivity on a long-term basis and thus increase farm income.

Benefits Attributed to Structural Measures

While it is recognized that some residual flooding will occur during extreme floods, the amount when brought to an average annual basis is so small that it was neglected in figuring benefits. Since residual damages are negligible, benefits attributed to structural measures consist of damages remaining after benefits attributed to land treatment measures have been deducted.

SURVEYS

CHESBRO RESERVOIR

"As constructed" drawings of the Elmer J. Chesbro reservoir, dam, spillway, and outlet works together with associated geological exploration served as the basic data for reservoir design. Field inspection of the site provided supplemental information. U. S. Geological Survey quadrangle topography was used to determine rough costs for alternate flood storage sites during project formulation.

CHANNEL IMPROVEMENT

Field cross sections and detailed mapping were provided by the Santa Clara County Flood Control and Water Conservation District for Llagas Creek from its mouth upstream to the proposed Little Llagas diversion near U. S. Highway 101 and for Miller Slough and West Branch Llagas Creek. These sections, following existing channel alignment, were taken wherever significant changes in channel configuration occurred. Horizontal control was established by a tape transit traverse and vertical control by rod and level using U.S. Geological Survey 1927 North American mean sea level datum. Topographical data for channels which do not follow existing creeks were obtained from field profiles using rod and stadia control and checked for general conformation with U. S. Geological Survey quadrangle maps for the area. Scattered cross sections of existing Llagas Creek were taken between U. S. Highway 101 and Chesbro Dam to determine whether or not channel improvement was needed and to design the short reach requiring improvement. All existing bridges were measured in the field in order to determine their present capacities and their influence on channel design and quantities. All utilities crossing or immediately alongside proposed structural measures were located and inspected in the field to determine if relocation or modification will be required.

HYDRAULIC DESIGN

CHESBRO RESERVOIR

All flood routings used in the hydraulic design of raising Chesbro Reservoir start with the water surface at the crest of the principal spillway when the flood begins. It has been further determined that an increase in sediment reservation will not be required as sediment production in the tributary area will be reduced by applying land treatment measures and trap efficiency will remain unchanged.

In the project formulation stage, the design inflow (the 1 percent 24-hour hydrograph) was routed through several sizes of principal spillway and thence downstream to be combined with the required local inflows to establish the design flow for each channel reach. All routing through the reservoir was accomplished by the storage indication method, and all routing within downstream channels was done by the Wilson method.

Final sizing of the principal spillway was accomplished by routing the 1 percent inflow for storms of several lengths and adjusting the spillway size until the optimum controlled flood storage of 3,570 acre-feet was reached. The 48-hour storm inflow proved to be most critical.

Final sizing of the emergency crest was accomplished by trial and error routing of the freeboard hydrograph (a 6-hour storm) until the outflow was held to the existing chute capacity of 11,000 cfs. The elevation of the dam crest was placed at the next even foot above highest water surface elevation during this routing. The maximum historical discharge carried by this chute was 3,000 cubic feet per second during the storm of April, 1958.

The proposed spillway crest structure consists of an 80 foot wide emergency crest with a 25 foot wide notch in its center to serve as the principal spillway. This control structure will discharge into an existing trapezoidal concrete-lined chute with a 25 foot bottom and 1.5 to 1 side slopes. Provision is made for model studies in conjunction with final design to determine detailed hydraulic properties of the spillway crest and the curved portion of the chute. A nominal increase in chute velocities is realized through the greater head, but this can be kept low enough not to materially affect chute or dissipator operation through proper final design of the crest. Precedence is found for the principle of notching the principal spillway into the emergency spillway from such dams as Arnold Dam built by the U. S. Bureau of Reclamation on the Colorado River in Texas.

CHANNEL IMPROVEMENT

During periods of flooding, Llagas Creek flows into, and is partially controlled by, Soap Lake. The 1 percent water surface elevation in Soap Lake delineates the lower limits of the benefited area and establishes the design water surface at the mouth of Llagas Creek. This elevation was established through a series of backwater curves and lake routings run on the Pajaro River between Chittenden gage and the Llagas Creek mouth.

Backwater curves were run by the standard step method with Manning's "n" for the existing channels determined by field inspection and from photos. Soap Lake routings were accomplished by use of the Steinberg method, which evaluates storage as a function of both inflow and outflow.

Channel design in areas having plastic soils is based on tractive force theory. The design relationship used for relating allowable tractive force and plastic index was developed by the U. S. Bureau of Reclamation and proved applicable to the Santa Clara Valley by evaluating those forces existing channels have successfully withstood. As an additional safety precaution, provision is made for seeding all unlined

channels. A Manning's "n" of 0.030 was used in hydraulic design to allow for vegetation as well as such minor losses as occur at curves and bridge piers. Design velocities have been maintained sufficiently high to accomplish enough sediment movement to prevent excessive deposition.

Channel design in areas with nonplastic soils is based on the limiting tractive force values obtained from Technical Release 13 of the Soil Conservation Service. Because of the impracticability of holding tractive force within these limiting values in an unlined channel and because the material in the banks is generally poorer than that in the bed, all channels in these soils are designed with riprapped sides and natural bottoms. The tractive forces on the bottom are evaluated by use of methods adopted from Einstein's sediment transport theory and limited to the values given in Technical Release 13 for material of the size of the predicted armor coat. The theoretical functioning of the design is for the fines to gradually wash downstream, leaving on the bottom an armor coat composed of the coarsest quarter of the existing bed load material. A Manning's "n" of 0.035 was used in hydraulic design and reflects the additional coarseness of bank and bed materials over that found in cohesive soils.

Designs in both types of material were provided with vegetated earth freeboard in amounts required by Soil Conservation Service criteria. In no case does the design slope reach 0.7 of critical.

Grade stabilization structures are used in this work plan where they are needed to keep design tractive forces within the allowable limits. Extensive use was made of available literature and recommended Soil Conservation Service criteria in designs for the purpose of cost evaluation.

Llagas Creek presently has sufficient channel capacity throughout a 7,000 foot reach opposite San Martin. However, because this reach is an integral part of the channel system upon which a proper functioning of the whole depends, provision is made to maintain it as part of this project. Cost associated with this reach includes purchase of right-of-way for channel and maintenance roads as well as five drainage inlets to bring local drainage into Llagas Creek.

STRUCTURAL DESIGN

CHESBRO RESERVOIR

Structural design of the raised Chesbro Reservoir conforms closely with that of the existing structure. The present homogeneous earth section is essentially preserved by adding similar material on the upstream face to achieve the 11 foot increase in crest elevation. An impervious blanket is provided on the right abutment to relieve an existing mild seepage problem. As the increased storage within the reservoir will only be utilized for periods not exceeding 10 days during major storms, there is no reason to expect any noticeable effect on seepage or general dam stability. The present small rock slope protec-

tion on the dam's upstream face will be removed before additional fill is placed, and higher quality riprap protection will be provided for the raised dam.

The modification required in conjunction with the existing outlet works involves extending the pipe, relocating the intake structure upstream from the toe of the proposed fill and relocating to an elevation above the new dam crest the oil pump locker used to hydraulically operate the emergency closure. The existing 56 inch welded steel pipe encased in 12 inches of reinforced concrete has sufficient strength to withstand the additional external and internal pressures. The pipe rests on a compacted earth foundation and has experienced some settlement; but even with the additional fill, amounts should remain too small to affect operation. The outlet works are operated by a gate at the downstream end and provided emergency closure hydraulically operated gates at the upstream end.

Dam foundation work is carried to the same depth used in constructing the existing structure. Stripping is provided wherever new fill contacts the existing ground and incluses removal of the existing dam facing. Cutoffs are extended up both abutments to the elevation of the new dam crest.

The existing L-shaped spillway crest is transformed into a straight crest perpendicular to the center line of the existing chute. Gravity retaining walls flanking both sides of the crest are designed to withstand the full hydrostatic head that will develop during the freeboard flood. The walls rest on Franciscan sandstone of sufficient strength to withstand the loading.

CHANNEL IMPROVEMENT

A basic concept used in channel improvement work is to keep the design water surface at or slightly below the existing ground elevation in order to allow local inflow of storm runoff. Thus, levees are used only to provide freeboard or across depressions in the existing profile. Side slopes of 2 to 1 are used throughout the project and should present no stability problems. Seeding is provided for all side slope areas not covered with riprap. A maximum bottom width to depth ratio of 10 to 1 was used throughout the project except for reaches on Llagas Creek within the existing percolation area where a wider channel was required to assure minimum disturbance and in the lower reaches where the channel transitions into Soap Lake.

Riprap protection is provided on both banks for all channels located in noncohesive soils, upstream and downstream from all grade stabilization structures, around drainage inlets, wherever required around existing bridges, at major transitions in channel section, and up each leg of all channel junctions. All curves having a radius under 800 feet are provided with riprap protection for earth channels and an increased riprap thickness for already lined channels. The riprap extends from the design water surface down to three feet below the proposed channel bottom to provide insurance against undermining. Soil Conservation Service criteria as outlined on pages 6-13 of the Far West States Engineering Design Standards were followed in establishing riprap thickness and rock size. Six inches of filter material is provided under all riprap.

Drainage inlets are provided to allow local drainage and storm runoff to enter the proposed channels at regular intervals. Estimates are based on average requirements without pinpointing specific locations.

Grade stabilization structures were checked generally to make sure that the provided quantities are sufficient to insure a structurally safe design.

Existing bridges over the improved channels were considered hydraulically adequate if they would pass the design flood with one foot of clearance and structurally adequate if the designed channel would not so expose the substructure as to endanger the stability of the bridge. Estimates for new bridges allow a length equal to the design water surface width.

Maintenance roadways are provided on both sides of all proposed channels except for limited areas through Gilroy where special maintenance agreements involving use of private roadways will be made.

COST ESTIMATION

LAND TREATMENT MEASURES

The unit costs for installation of on-farm land treatment measures were based on current costs of materials and construction. For those practices involving farm labor and equipment, costs were derived from recent studies made by the Soil Conservation Service in the area. Construction costs for roads, firebreaks, helispots, and water tanks were based on contract prices for similar work in other areas. Costs of fire operation and the maintenance of fire control measures were derived from averages of such costs as tabulated in existing records and amount to $1,800 annually.

The cost of technical assistance for the installation of land treatment measures was based upon previous work by Forestry personnel and an analysis of Soil Conservation Service expenditures and soil conservation district accomplishments for the past several years in the Loma Prieta Soil Conservation District.

STRUCTURAL MEASURES

Construction Costs

Construction costs are based on quantities calculated for the proposed structural measures and estimated average unit costs of the individual items. Unit costs are based on actual bid prices for similar works under comparable conditions in the northern part of Santa Clara County and upon analysis of other applicable cost data which were furnished by various agencies. For some complex items, such as drainage inlets, unit costs were estimated from tentative designs on a per each basis. The estimated contract costs, based on quantities, were increased 15 percent for contingencies.

Unit costs are as follows:

Chesbro Reservoir:

Concrete in spillway area	$	45.00 per cu. yd.
in slope paving		60.00 per cu. yd.
Excavation - rock		20.00 per cu. yd.
- earth		1.00 per cu. yd.
- concrete removal		25.00 per cu. yd.
Embankment - dam		0.80 per cu. yd.
- impervious blanket		0.90 per cu. yd.
Rock riprap		6.00 per cu. yd.
Filter material		2.00 per cu. yd.

Channel Improvement:

Concrete - structural		90.00 per cu. yd.
Excavation - common		0.45 per cu. yd.
- moderately congested urban areas		1.50 per cu. yd.
- heavily congested urban areas with limited access		3.00 per cu. yd.
Rock riprap		6.00 per cu. yd.
Filter material		4.00 per cu. yd.
Drainage inlets - earth channel		1,500.00 each
- rocked channel		1,300.00 each
Seeding		200.00 per acre
Railroad bridge - single track		300.00 per lineal ft.

Installation Services

A composite installation service cost was estimated as 22.5 percent of the construction cost plus additional sums of $5,000 for hydraulic model studies for Chesbro Reservoir and $20,000 for the geologic exploration of various possible riprap source sites. The percentage value includes engineering and Federal administrative functions on project, State, and national levels. Engineering consists of performing final construction surveys, final design of structural measures, preparation of plans and specifications, and supervision of construction.

Right-of-Way Costs

Right-of-way costs were provided by the Santa Clara County Flood Control and Water Conservation District based on field inspection by their personnel and sales recently completed in the immediate vicinity. Land values per acre ranged between $100 and $7,000 depending on location and present land use except for limited areas in Gilroy where values reached $.50 per square foot for residential property and $500 per frontage foot for commercial property. To the above costs were added the estimated values of buildings or other improvements presently located within the required right-of-way. All costs are based on fee title acquisition of the required property even though actual construction may be completed on the basis of easements in some instances. The computed costs were increased by a factor of 15 percent for acquisition costs.

Utility Modification Costs

Unit costs for new bridges were furnished by Santa Clara County and the California Division of Highways. Eight dollars per square foot was used for private wooden bridges and 15 dollars per square foot for county and State bridges. Costs for the two fords across Llagas Creek were determined from preliminary designs and the unit costs used for structural measures.

The cost for road relocations in the vicinity of Chesbro Reservoir was estimated by Santa Clara County based on a feasibility type design and unit costs currently prevailing in the area.

Other utility modification costs (various pipe lines, telephone cables, power poles, wells, etc.) were obtained from the utility company or other owner involved and checked against the experience of the Santa Clara County Flood Control and Water Conservation District in relocating similar type utilities elsewhere in the county.

Administration of Contracts

An allowance of 1 percent of the total construction cost was included for the local administration of contracts. State dam filing fees amount to $4,700 and are based on the construction cost of raising Chesbro Dam including the revision to the outlet works.

Allocating Costs Between Evaluation Units

All costs were allocated to the Llagas Creek evaluation unit except for the cost associated with channel improvement located within the West Branch Llagas Creek evaluation unit plus a portion of the cost associated with the Day Road diversion. The cost associated with the diversion was the sum of the installation cost of the diversion channel and the incremental installation cost on Llagas Creek to handle the additional flows. This cost was then allocated between the two evaluation units by a ratio determined from the location of the savings effected in channel construction through Gilroy. Since it was found that 38.5 percent of the savings were effected within the West Branch Llagas Creek evaluation unit, it was this portion of the diversion channel cost that was attributed to this subunit. Total installation costs by economic evaluation unit were thus found to be $1,228,000 on West Branch Llagas Creek and $6,109,500 on Llagas Creek.

Cost Sharing on Chesbro Reservoir Outlet Works

In order to determine the cost sharing percentages to be applied in the cost sharing associated with revising the Chesbro Reservoir outlet works, an analysis was made of the ratio of other than direct identifiable benefits to total benefits. As this ratio was found to be 0.70, the Public Law 566 share of relocating this agricultural water management facility was set at the 46 percent maximum. In accordance with this maximum percentage, cost sharing on this item was assigned in the following manner:

	Total	Public Law 566 Funds	Other Funds
Construction cost	$23,000	$ 8,100	$14,900
Installation services	5,000	5,000	
Contract administration and State dam filing fees	500		500
Installation cost	$28,500	$13,100	$15,400
Installation cost share		(46%)	(54%)
Construction cost share		(35.2%)	(64.8%)

Operation and Maintenance

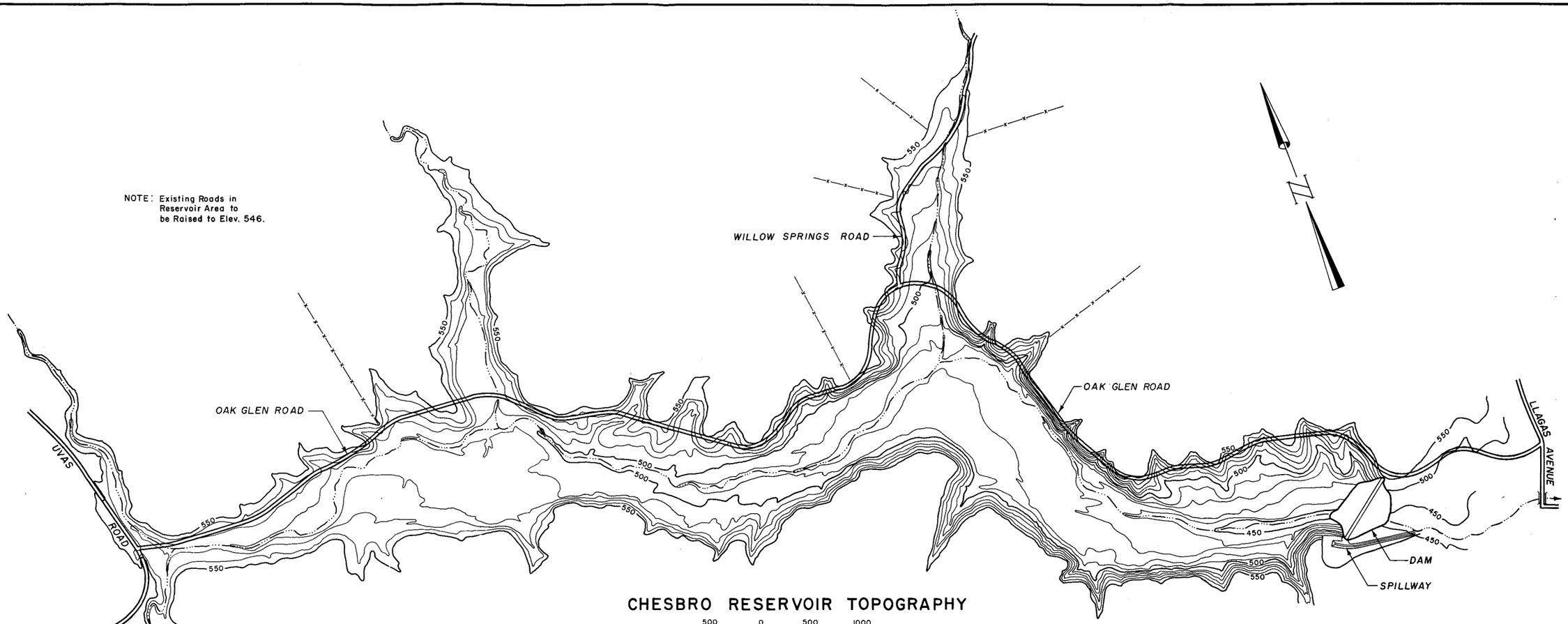
The estimated average annual cost for the operation and maintenance of structural measures is $38,000. This was estimated by an analysis of the actual work which would be required to properly maintain and operate the various works. Basic data for the analysis was furnished by several local and State agencies which have had extensive experience in this field. The annual cost given above is adjusted to long-term projected price levels and equals 1 percent of the construction cost.

Average Annual Equivalent Cost

The total average annual equivalent cost for watershed flood prevention structural measures is composed of the amortized total installation cost plus annual operation and maintenance. The total installation cost is amortized over 50 years at an interest rate of 2-5/8 percent.

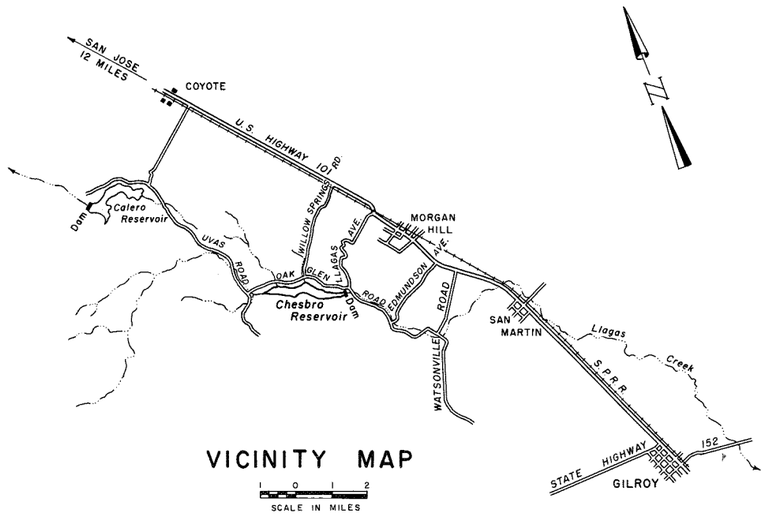
The benefit-cost ratio is the average annual benefits divided by the average annual equivalent cost.

NOTE: Existing Roads in Reservoir Area to be Raised to Elev. 546.



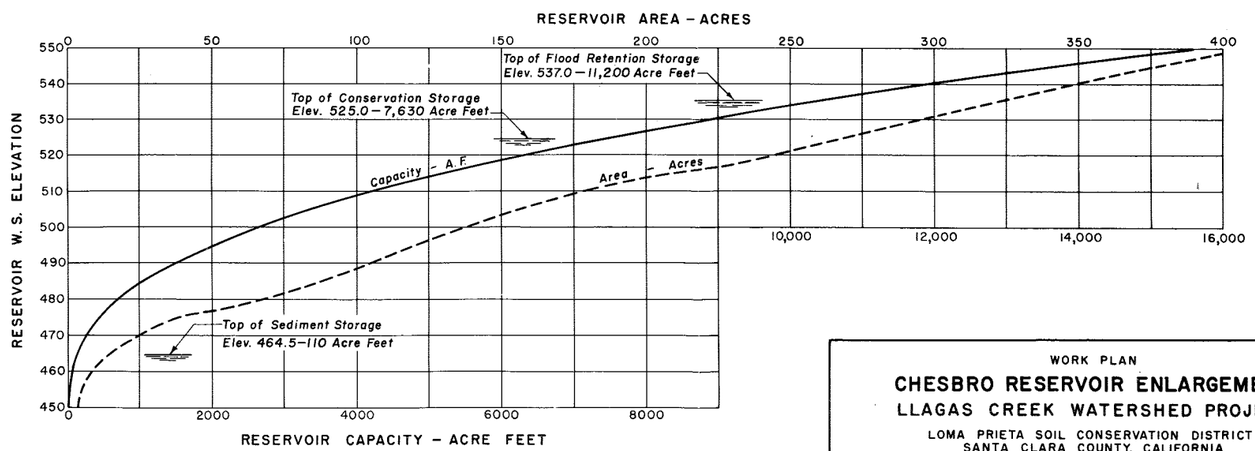
CHESBRO RESERVOIR TOPOGRAPHY

500 0 500 1000
SCALE IN FEET
CONTOUR INTERVAL 10 FEET



VICINITY MAP

1 0 1 2
SCALE IN MILES



AREA – CAPACITY CURVES

WORK PLAN

CHESBRO RESERVOIR ENLARGEMENT

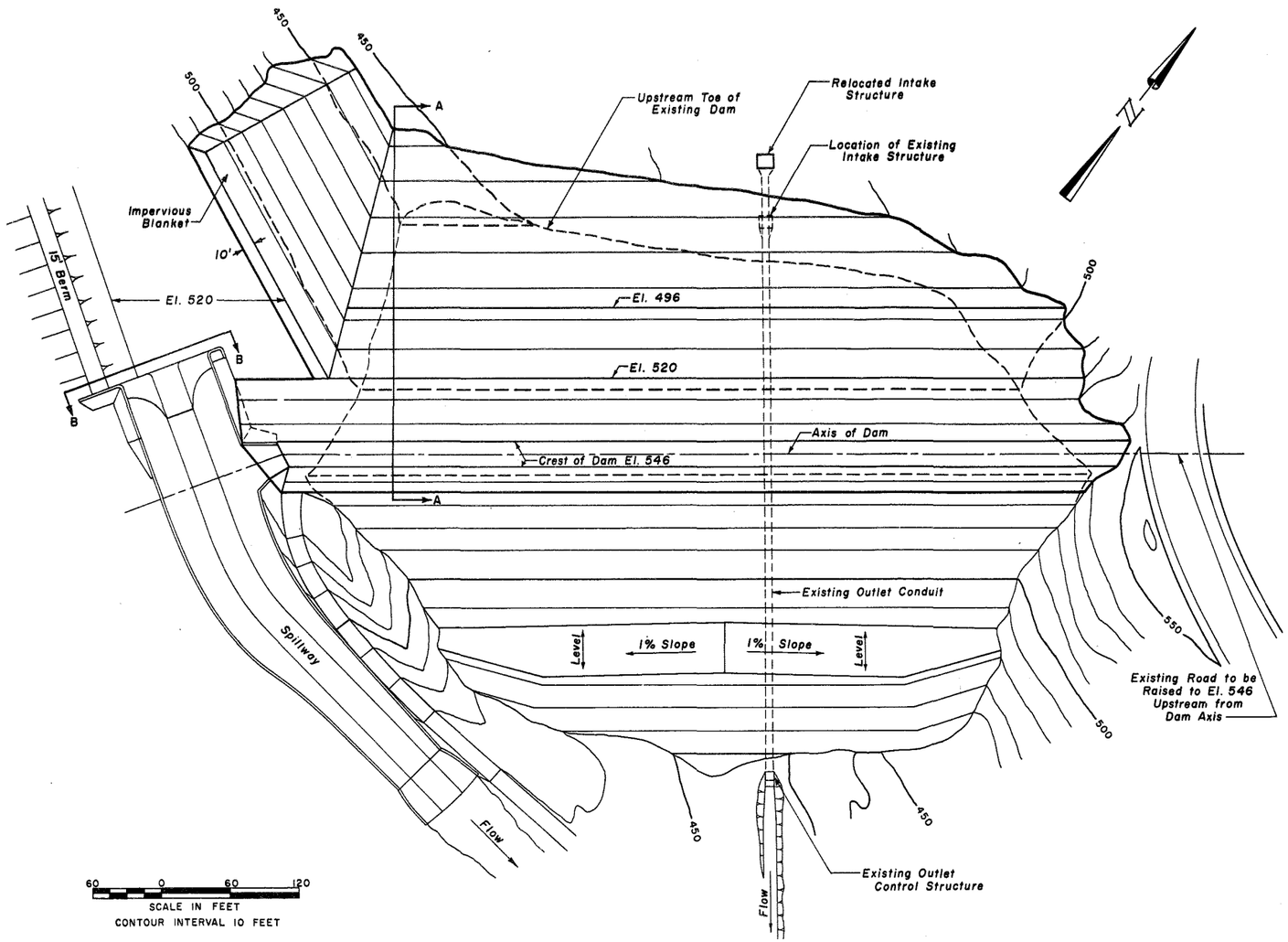
LLAGAS CREEK WATERSHED PROJECT

LOMA PRIETA SOIL CONSERVATION DISTRICT
SANTA CLARA COUNTY, CALIFORNIA

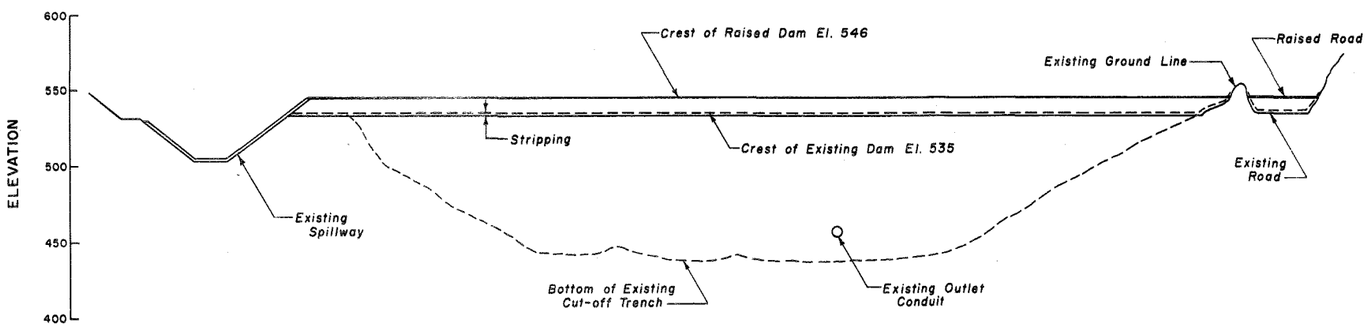
PRELIMINARY PLANS

THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION, DIVISION OF SOIL CONSERVATION
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

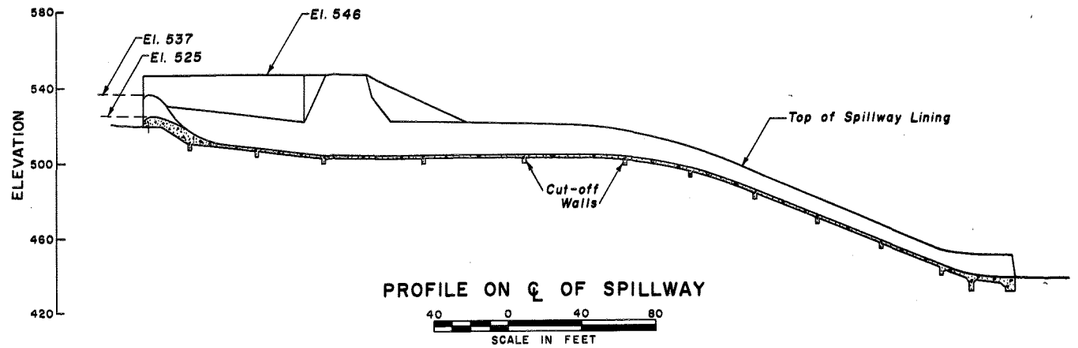
Prepared by S.D.S.C. Date JAN. 1962 Dwg. No. C-1



PLAN

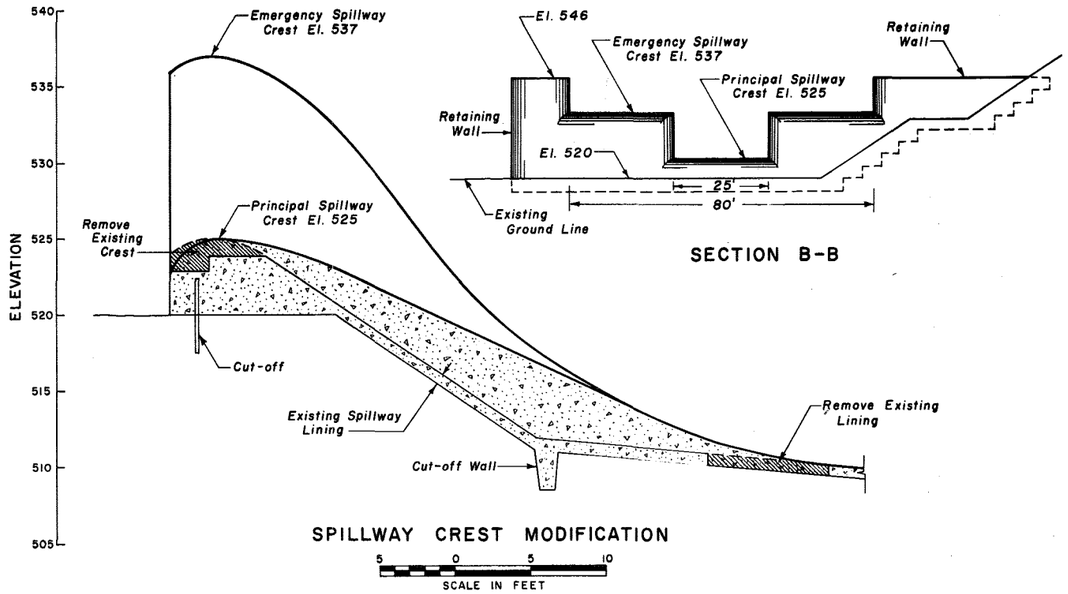


PROFILE ON AXIS OF DAM



PROFILE ON ℄ OF SPILLWAY

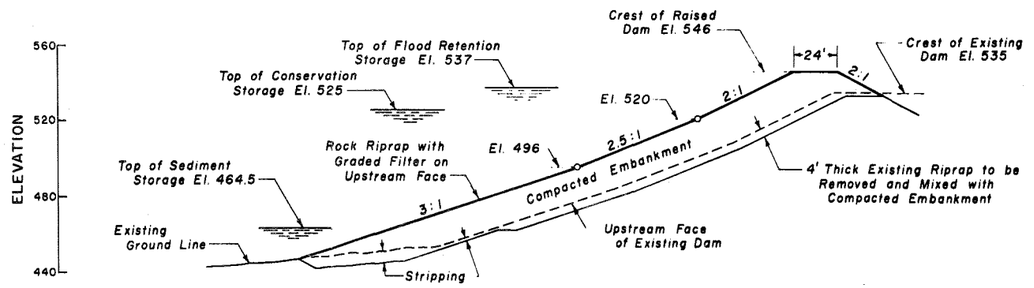
40 0 40 80
SCALE IN FEET



SECTION B-B

SPILLWAY CREST MODIFICATION

5 0 5 10
SCALE IN FEET



SECTION A-A

40 0 40 80
SCALE IN FEET

WORK PLAN

CHESBRO DAM MODIFICATION

LLAGAS CREEK WATERSHED PROJECT

LOMA PRIETA SOIL CONSERVATION DISTRICT
SANTA CLARA COUNTY, CALIFORNIA

PRELIMINARY PLANS

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U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by S.D.S.C. Date JAN. 1962 Dwg. No. C-2

R. 4 E.

T. 11 S.
T. 10 S.

RANCHO DE LAS ANIMAS

RANCHO SAN YSIDRO (GILROY)

RANCHO SAN YSIDRO (ORTEGA)

RANCHO DE LAS ANIMAS

RANCHO SAN FRANCISCO DE LAS LLAGAS

RANCHO DE LA POLKA

Approximate Boundary Soap Lake Area at Max. Flood Stage

Beginning of Improved Channel Sta. 92+00

Proposed New Bridge Sta. 127+40

Relocate Power Pole

Relocate Irrig. Pipe

Relocate Power Pole, Well, & Pump

Miller Slough

PRINCEVALLE DRAIN

Sta. 191+00 Llagas = Sta. 0+00 Miller Slough

Proposed Miller Slough Channel (SEE DWG. NO. M-11)

Relocate Power Pole

Relocate Residence

Relocate Gas Main Sta. 175+00

Proposed New Bridge Sta. 175+60

Llagas

HOLSCLAW

Relocate Well & Pump

Relocate Barn

Landing Strip

Proposed New Bridge Sta. 238+90

Relocate Power Poles

Relocate Well & Pump

Relocate Power Poles

Proposed New Bridge Sta. 297+80

Relocate Gas Main Sta. 297+95

Relocate Power Pole

Sta. 357+50 Llagas = Sta. 0+00 West Branch Llagas

Proposed West Branch Llagas Channel (SEE DWG. NO. WBL-1)

Creek

Live Oak Creek

Panther Creek

Skillet Creek

FRAZIER LAKE ROAD

PACHEDO PASS

PACHECO PASS HWY

FURLONG AVENUE

Alamias Creek

MARCELLA AVENUE

NEW AVENUE

CENTER AVE

HIGHWAY 152

GRANT RD.

LEAVESLEY ROAD

GODFREY AVENUE

LAS ANIMAS AVENUE

BUENA VISTA AVENUE

DRILL HOLE LEGEND

L-7 (Hole Number)
(Sample No.) 1 — NP (Non-Plastic)
Well-Graded Sand and Gravel, GW
Poorly Graded Sand and Gravel, GP
Clayey Gravel, GC
Gravelly Sand, SW
Clayey Sand, SC
Silty Sand, SM
Fat Clay, CH
Lean Clay, CL
(Sample No.) 2 — 24 (Plasticity Index)

PLAN

1000 0 1000 2000
SCALE IN FEET

LEGEND

Existing Channel
Improved Channel
Drill Hole Location
Existing Levees

TABLE OF VARIABLES IN TYPICAL SECTION

Beginning Sta.	Ending Sta.	b	Depth of Water	t
92+00*	107+50	182'	10.0'	
107+50	150+00	107'	15.0'	
150+00	191+00	130'	15.0'	12"
191+00	298+90	118'	12.5'	15"
298+90	314+00	112'	13.0'	
314+00	329+40	110'	13.0'	
329+40	357+50	107'	13.0'	
357+50	386+30	100'	10.5'	

*Transition to existing channel sta. 92+00 to sta. 95+00.

TYPICAL SECTION
Sta. 92+00 to Sta. 150+00
Sta. 298+90 to Sta. 386+30

TYPICAL SECTION
Sta. 150+00 to Sta. 298+90

ELEVATION - U.S.G.S. MEAN SEA LEVEL DATUM

ELEV. 182 - APPROXIMATE W.S. OF SOAP LAKE AT MAX. FLOOD STAGE

Existing Ground
Proposed Ground
Water Surface
Existing Channel Bottom
Proposed Channel Bottom
Riprap
Filter
Levees
Proposed Drop Structure
Proposed Pipe Bridge (Buried)
Proposed Miller Slough Bridge
Proposed Gilman Road Bridge
Proposed Leavesley Road Bridge (Near)
Proposed Grant Road Bridge
Proposed Frice Avenue Bridge
Proposed Miller Slough Structure
Proposed West Branch Llagas Structure
Proposed Skillet Creek Structure
Proposed Panther Creek Structure
Proposed Live Oak Creek Structure

100+00 120+00 140+00 160+00 180+00 200+00 220+00 240+00 260+00 280+00 300+00 320+00 340+00 360+00 380+00

WORK PLAN
LLAGAS CREEK
LLAGAS CREEK WATERSHED PROJECT

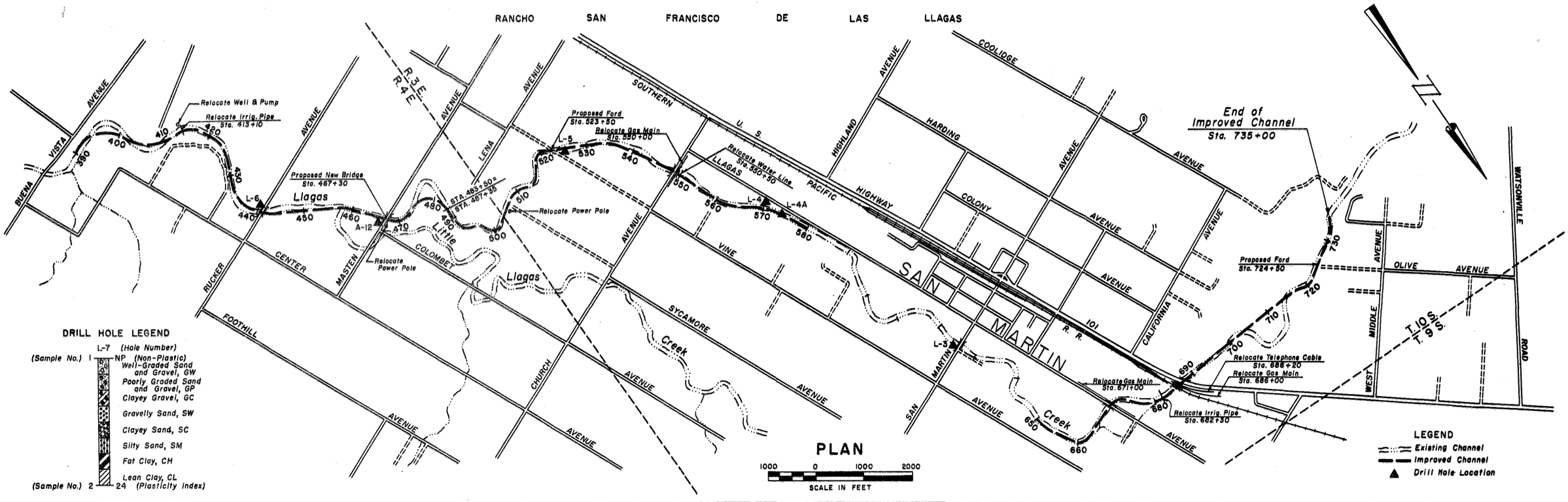
LOMA PRIETA SOIL CONSERVATION DISTRICT
SANTA CLARA COUNTY, CALIFORNIA

PRELIMINARY PLANS

THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION, DIVISION OF SOIL CONSERVATION
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by S.D.S.C. Date JAN. 1962 Dwg. No. L-1

RANCHO SAN FRANCISCO DE LAS LLAGAS



PLAN

1000 0 1000 2000
SCALE IN FEET

DRILL HOLE LEGEND

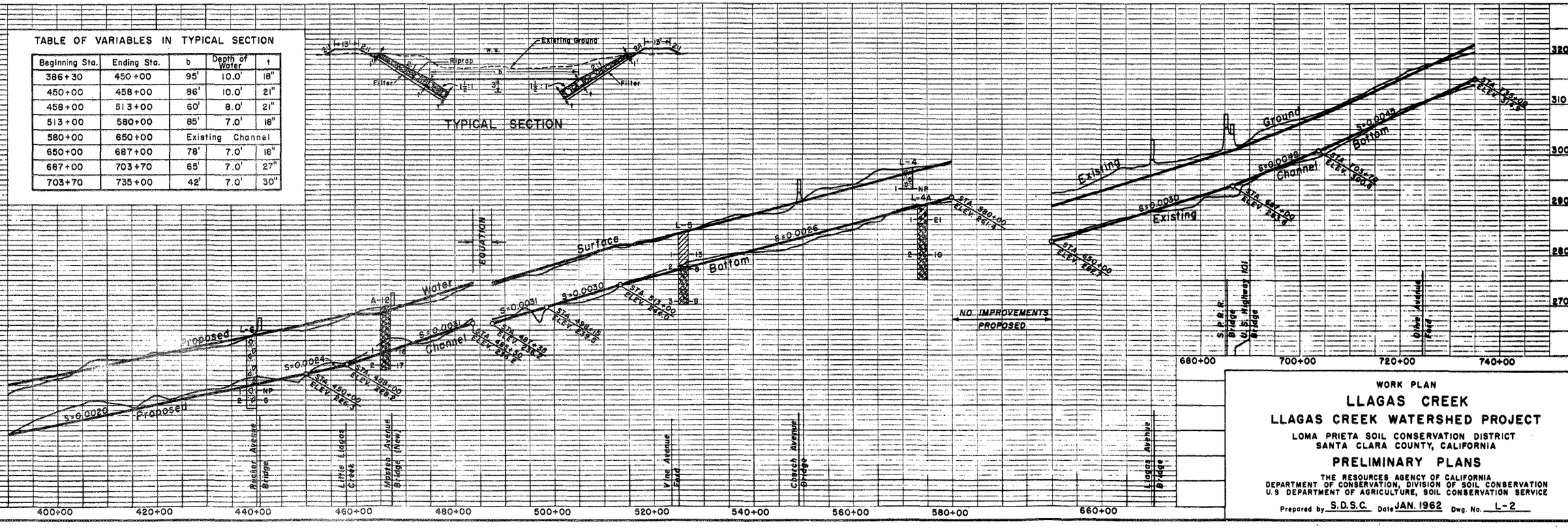
L-7 (Hole Number)
(Sample No.) 1 — NP (Non-Plastic)
Well-Graded Sand and Gravel, GW
Poorly Graded Sand and Gravel, GP
Clayey Gravel, GC
Gravelly Sand, SW
Clayey Sand, SC
Silty Sand, SM
Fat Clay, CH
Lean Clay, CL
(Sample No.) 2 — 24 (Plasticity Index)

LEGEND
- Existing Channel
- Improved Channel
- ▲ Drill Hole Location

TABLE OF VARIABLES IN TYPICAL SECTION

Beginning Sta.	Ending Sta.	b	Depth of Water	t
386+30	450+00	95'	10.0'	18"
450+00	458+00	86'	10.0'	21"
458+00	513+00	60'	8.0'	21"
513+00	580+00	85'	7.0'	18"
580+00	650+00	Existing Channel		
650+00	687+00	78'	7.0'	18"
687+00	703+70	65'	7.0'	27"
703+70	735+00	42'	7.0'	30"

TYPICAL SECTION



WORK PLAN

LLAGAS CREEK

LLAGAS CREEK WATERSHED PROJECT

LOMA PRIETA SOIL CONSERVATION DISTRICT
SANTA CLARA COUNTY, CALIFORNIA

PRELIMINARY PLANS

THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION, DIVISION OF SOIL CONSERVATION
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RANCHO DE LAS ANIMAS

RANCHO SAN YSIDRO (GILROY)

Beginning of Improved Channel Sta. 0+00

Sta. 0+00 Miller Slough = Sta. 191+00 Llagas

End of Improved Channel Sta. 180+00

End of Improved Channel Sta. 212+00

End of Improved Channel Sta. 220+00

T.11S. T.10S. R.3E R.4E

PLAN

1000 0 1000 2000

SCALE IN FEET

LEGEND

- Existing Channel
- Improved Channel
- Drill Hole Location

DRILL HOLE LEGEND

L-7 (Hole Number)

(Sample No.) 1 — NP (Non-Plastic)

- Well-Graded Sand and Gravel, GW
- Poorly Graded Sand and Gravel, GP
- Clayey Gravel, GC
- Gravelly Sand, SW
- Clayey Sand, SC
- Silty Sand, SM
- Fat Clay, CH
- Lean Clay, CL

(Sample No.) 2 — 24 (Plasticity Index)

TABLE OF UTILITIES TO BE RELOCATED

1. Immediately downstream from Sixth Street Bridge relocate 300 feet of 4 inch water line and one water meter.
2. Lewis Street Bridge relocate Sewer Line.
3. Forrest Street Bridge relocate Sewer Line and relocate Buried Gas Line.
4. I.O.O.F. Avenue Bridge relocate Sewer Line.
5. Gilroy Highschool Stadium relocate 8 Electroliers.
6. Above Welburn Avenue — Well and Pump.

TABLE OF VARIABLES IN TYPICAL SECTION

Beginning Sta.	Ending Sta.	b	Depth of Water
0+00	20+00	18.0'	15.0'
20+00	60+00	8.0'	15.0'
60+00	92+00	60.0'	6.0'
92+00	130+00	38.0'	6.0'
130+00	160+00	32.0'	6.0'
160+00	180+00	4.0'	4.0'
North Channel			
160+00	175+00	20.0'	6.0'
175+00	220+00	9.0'	6.0'
South Channel			
175+00	212+00	9.0'	4.8'

TYPICAL SECTIONS

Sta. 92+00 to Sta. 106+00

Sta. 60+00 to Sta. 92+00
Sta. 106+00 to Sta. 145+00
Sta. 160+00 to Sta. 180+00

Sta. 0+00 to Sta. 60+00
Sta. 145+00 to Sta. 160+00
North Channel
South Channel

ELEVATION - U.S.G.S. MEAN SEA LEVEL DATUM

Proposed Water Surface
Existing Ground
Existing Channel Bottom
Proposed Channel Bottom
Existing Bridges
Projected M-9
M-8
M-7
S=0.0005
S=0.0010
S=0.0015
S=0.0020
S=0.0030

Llagas Creek
Proposed Drop Structure
A.G.&E. Bridge (New)
Sixth Street Bridge
Lewis Street Bridge
Forrest Street Bridge
Private Road Bridge
I.O.O.F. Avenue Bridge
S.P.R.R. Monterey Street Bridge
Church Street Bridge
Welburn Avenue Bridge
Stream Junction
Ronan Avenue Bridge
Morey Avenue Bridge (New)
Wren Avenue Bridge (New)
Kern Avenue Bridge (New)

0+00 20+00 40+00 60+00 80+00 100+00 120+00 140+00 160+00 180+00 160+00 180+00 200+00 220+00 180+00 200+00

WORK PLAN

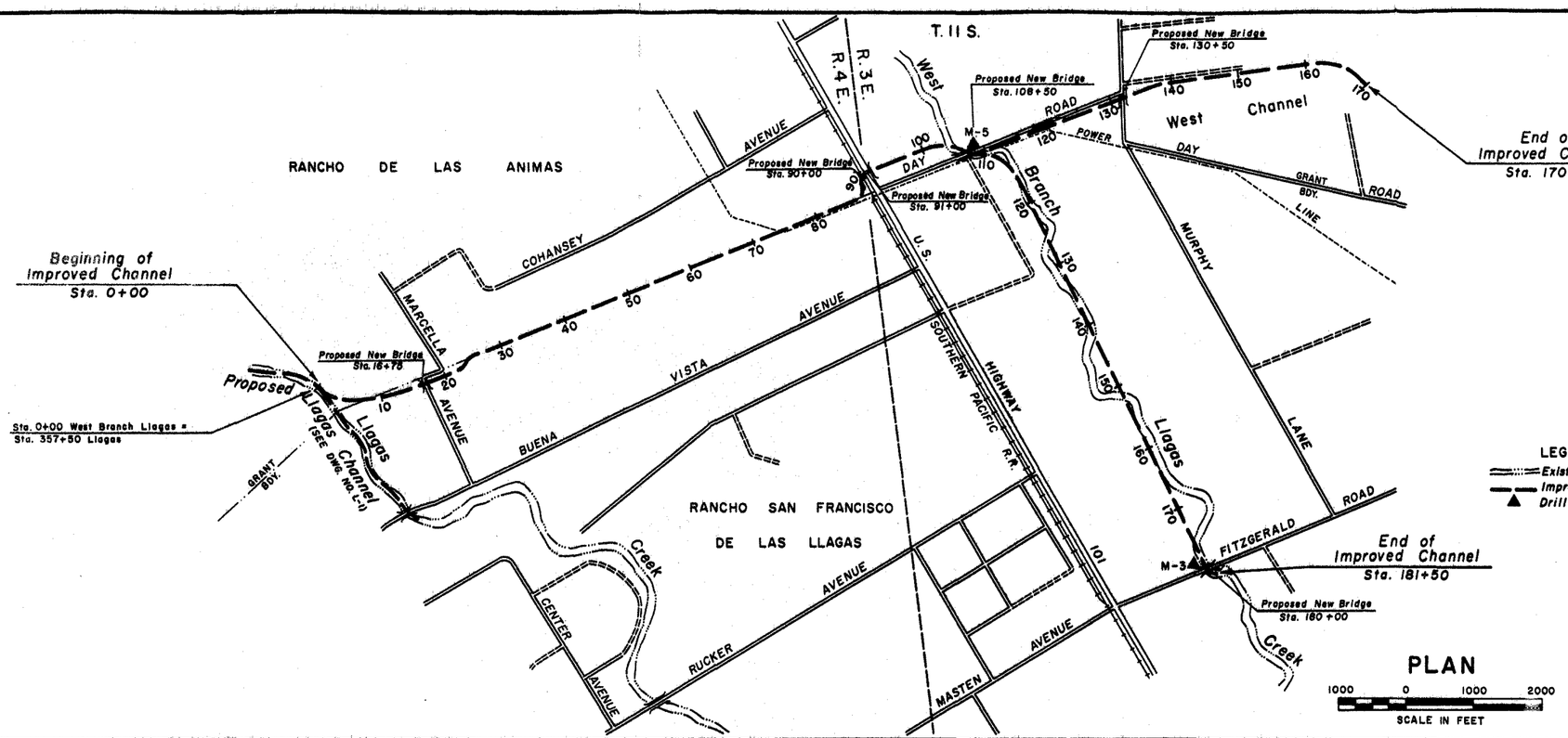
MILLER SLOUGH
LLAGAS CREEK WATERSHED PROJECT

LOMA PRIETA SOIL CONSERVATION DISTRICT
SANTA CLARA COUNTY, CALIFORNIA

PRELIMINARY PLANS

THE RESOURCES AGENCY OF CALIFORNIA
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U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by S.D.S.C. Date JAN. 1962 Dwg. No. M-1



LEGEND

- Existing Channel
- Improved Channel
- Drill Hole Location

DRILL HOLE LEGEND

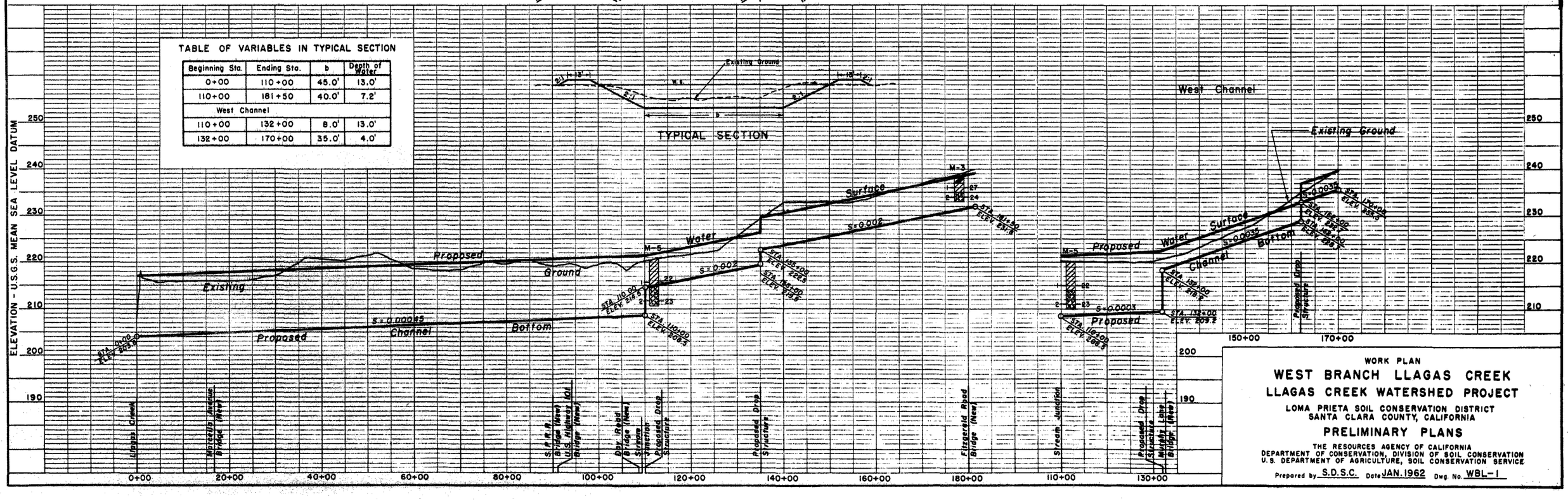
L-7 (Hole Number)
(Sample No.) 1 — NP (Non-Plastic)
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Poorly Graded Sand and Gravel, GP
Clayey Gravel, GC
Gravelly Sand, SW
Clayey Sand, SC
Silty Sand, SM
Fat Clay, CH
Lean Clay, CL
(Sample No.) 2 — 24 (Plasticity Index)

PLAN

1000 0 1000 2000
SCALE IN FEET

TABLE OF VARIABLES IN TYPICAL SECTION

Beginning Sta.	Ending Sta.	b	Depth of Water
0+00	110+00	45.0'	13.0'
110+00	181+50	40.0'	7.2'
West Channel			
110+00	132+00	8.0'	13.0'
132+00	170+00	35.0'	4.0'



WORK PLAN

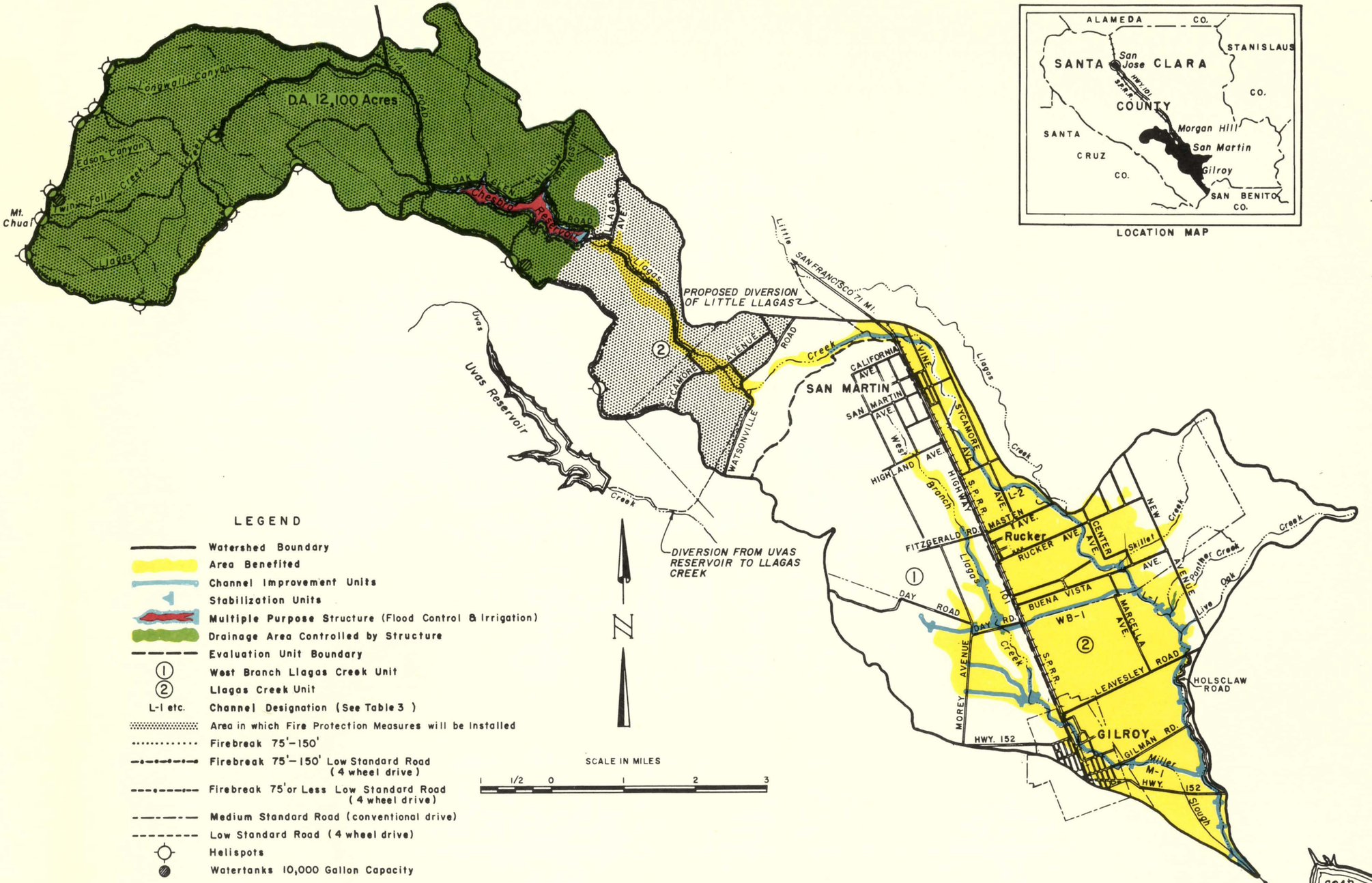
WEST BRANCH LLAGAS CREEK
LLAGAS CREEK WATERSHED PROJECT

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SANTA CLARA COUNTY, CALIFORNIA

PRELIMINARY PLANS

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U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by S.D.S.C. Date JAN. 1962 Dwg. No. WBL-1



PROJECT MAP

LLAGAS CREEK WATERSHED PROJECT

LOMA PRIETA SOIL CONSERVATION DISTRICT
SANTA CLARA COUNTY, CALIFORNIA

PRELIMINARY PLANS

THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF CONSERVATION, DIVISION OF SOIL CONSERVATION
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Prepared by S.D.S.C. Date JAN. 1962

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